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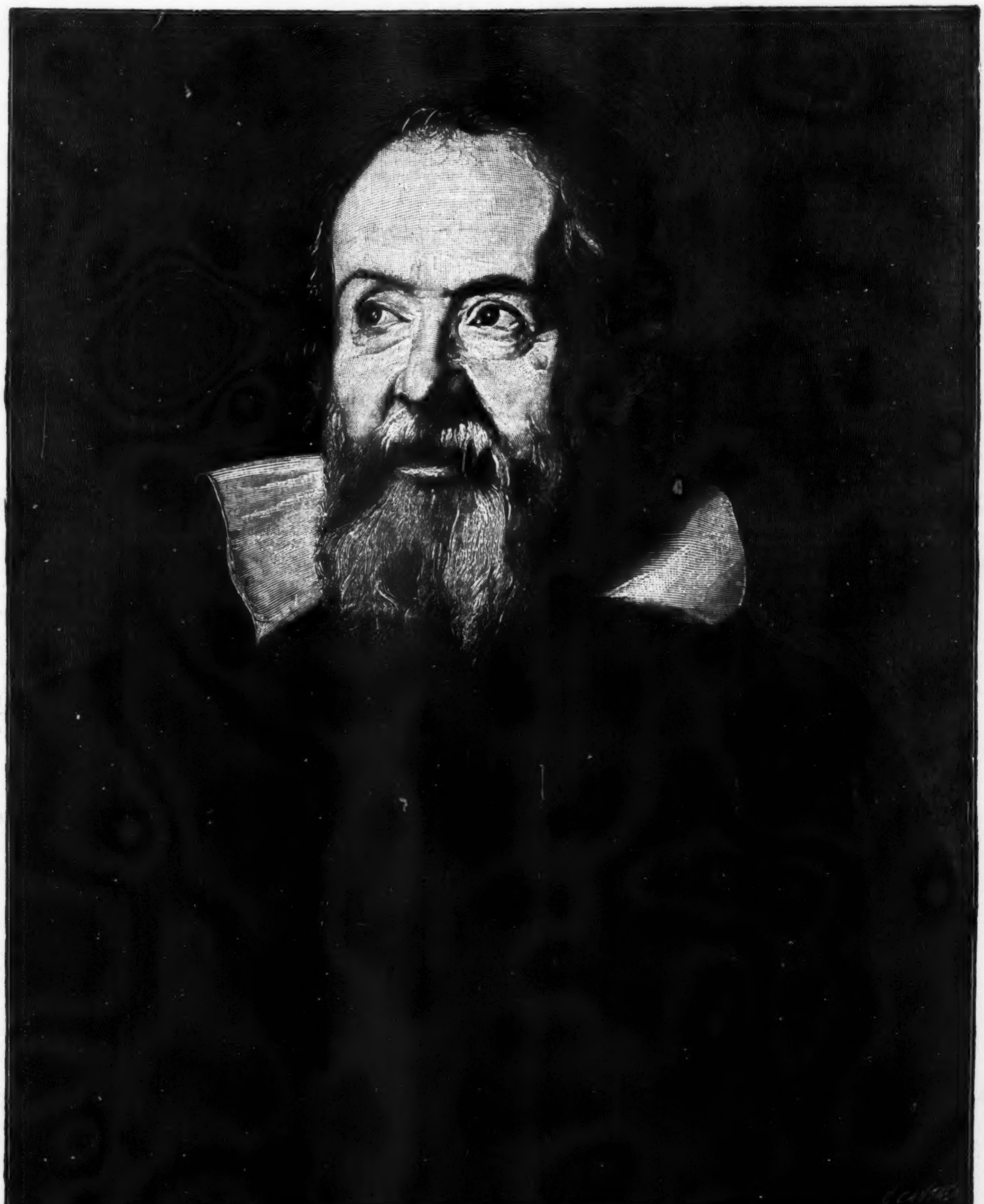
## GALILEO GALILEI.

THE 7th of last December the old and famous University of Padua celebrated with great solemnity and pomp the three hundredth anniversary of the day on which Galileo took the chair of physics in that institution. Mementoes of the life of the great man had been solicited, and these it seems worth while to reproduce here, for we are always glad to offer homage to genius, especially when the genius is as useful to mankind as that of the Italian savant has been.

Galileo was born in Pisa in 1564, of a noble family originally from Florence, and his parents had him pursue the course of medicine and philosophy in the university of his native city; but the peripatetic doctrines which predominated at that time did not satisfy his penetrating intelligence. He opposed the doctrines of Aristotle, which brought upon him the antagonism of his professors, and from this we get the key to the struggles of his after life. He was already an alumnus of the university when, at the age of nineteen, he made one of his most wonderful discoveries. He was in the cathedral one day when his gaze was attracted to a lamp that was suspended from the roof and to which the sacristan had just communicated an oscillating movement in lighting it. Galileo noticed that the oscillations were of the same duration, although their



GALILEO GALILEI.

**From a photographic copy of Substermans' celebrated portrait, in the Uffizi gallery, Florence.**

amplitude diminished little by little, and this gave him the idea of applying the pendulum to the measure of time, an idea which he again considered years later, but which was not realized until after his death.

But the discovery that really immortalized him was that of the laws of the movements of bodies subject to the action of gravity.

In order to understand the important part taken by Galileo in modern cosmic discoveries, it is only necessary to consider the ideas in regard to the universe that predominated in the minds of men who lived before and even after him.

To obtain a rational explanation of the movements of the celestial bodies, the ancients needed a principle that was also rational, by which they could co-ordinate all these movements, but they had no intuitive conception of the truth, and had recourse to the geometrical axiom that everything in the universe could be explained by circular and uniform movement. Thus they accepted it as the basis of abstract and subjective principles that were neither demonstrated nor demonstrable, to which they tried to reduce the world as in a Procrustes bed.

The science of movement was unknown to the ancients; that is, the knowledge of the laws that govern it and connect it inseparably with the forces by which it is produced; neither did they know that this science and the physical law of universal gravitation had transformed the problem of the universe from a question of geometry to one of pure mechanics.

Galileo was the creator of the science in question; the first to analyze the acceleration acquired by movement on account of the action of a constant force; the first to base the complete theory of heavy bodies that fall with a rectilinear movement on the conceptions of inertia, acceleration and component and resultant movements; and the first to analyze exactly the curvilinear parabolic movement of bodies that were thrown obliquely. He was also the one who opened, cleared, to use Foscolo's expression, the ways of the firmament for the flights of Newton, the English savant.

Copernicus gave back to the earth the theory of its movement that had been divined, rather than demonstrated, by some ancient schools; Galileo defended with all his might and spread the bold idea that the earth moved, and we with it, through interplanetary space, and studied the movement of bodies on the surface of the earth that were attracted toward its center; Kepler discovered the experimental laws of the central movement; Newton, reducing them all synthetically and co-ordinating them, demonstrated the fact that the force that causes all objects to fall to the surface of the ground is the same as that which causes the planets to circle around the sun, obeying the laws deduced experimentally by Kepler.

Copernicus, Galileo, Kepler, Newton, are names inseparably connected with the discovery of universal gravitation and the new ideas in regard to the universe.

We now say "everything moves," generalizing the *e pur si muove* attributed to Galileo. The prolific idea of movement originated, in fact, with the Copernican system; but the Italian physicist understood how to make a new science of it. In the first place, he recognized it and applied it to the grand solar system, and in developing it followed a method quite the opposite of the common beaten track; from the solar system he descended to the lesser systems of all the planets, from them to the planets themselves, to each cosmic body, to each terrestrial body, and finally to each molecule.

But these most important discoveries, these triumphs of the talent and observation of Galileo, were not attained by the great man without exciting the hatred of theologians and peripatetics who, rejecting his ideas, showed themselves ardent partisans of the belief that the earth did not move. They began to calumniate him at the pontifical court, saying that his astronomical opinions and his discoveries were contrary to various passages of the Holy Scriptures.

Before daring to accuse him openly they set a trap for him; they denounced the doctrines of Copernicus to the Holy See, with the evident object of forcing him to come out in their defense, as it was easy to suppose he would. Galileo defended them because he knew they were the truth, but he did it with clever prudence. He said that the passages of the Bible which were opposed to the scientific truth had been badly interpreted, and, besides, that the purpose of the Holy Scriptures was the salvation of men, and not the teaching of astronomy. These declarations did not satisfy the judges, who pronounced the following sentence: "To maintain that the sun is placed immovably in the center of the world is an absurd opinion, false philosophically and formally heretical, because it is expressly contrary to the Scriptures. To maintain that the earth is not in the center of the world, that it is not an immovable point, and that it has a movement of rotation, is also an absurd proposition, false philosophically and no less heretical in the faith."

When this sentence was communicated to Galileo he was warned by Cardinal Bellarmine that in future he must abstain from defending the condemned ideas. Galileo promised, and hurried to return to Florence. Once there, he thought that he was not obliged to obey, and instead of changing his opinion in regard to the movement of the earth and the rotation of the sun on its axis, he maintained the new system with more ardor than ever and devoted himself to collecting the necessary proofs to make him triumphant. He conceived the idea of writing a book that would bring the truths that he had discovered within reach of all intelligent people, and he published it in 1632 under the title "Dialoghi quatro, sopra i due massimi sistemi del mondo, Ptolomaico et Copernicanum." The work was delivered to the Inquisition, and Galileo, at the age of seventy, had to appear before the tribunal. He reached Rome February 10, and was confined in the Palace of Trinidad del Monte, residence of the Ambassador of Tuscany, where he was treated with a certain consideration. He was secretly advised to make amends for the enormous scandal that he had caused by proclaiming the movement of the earth, which is absurd, for it is written: *Terra autem in æterum stabit quia in æterum stat.* To all the astronomical proofs given by the savant they answered that it would have been impossible for Joshua to have stopped the sun if it had been a fixed star, as Galileo maintained. The scientific proofs were received with indifference.

The trial lasted twenty days. Galileo, intimidated by the severity of his judges and seeing that his reasoning could not be understood by such obtuse intelligences, abandoned, so to speak, his own defense. The debate was declared closed, and they ordered that he should solemnly abjure his doctrine. The ceremonial was prepared beforehand. The illustrious old man knelt before his judges, and, with his hand placed on the Bible and his head bowed, pronounced the following words:

"I, Galileo Galilei, son of the late Vincenzo Galilei, Florentine, aged seventy years, arraigned personally before this tribunal, and kneeling before you, most eminent and reverend lord cardinals, inquisitors general against heretical depravity throughout the whole Christian Republic, having before my eyes and touching with my hands the holy Gospels, swear that I have always believed, do now believe, and by God's help will for the future believe, all that is held, preached and taught by the Holy Catholic and Apostolic Roman Church. But whereas, after an injunction had been judicially intimated to me by this Holy Office, to the effect that I must altogether abandon the false opinion that the sun is the center of the world and immovable, and that the earth is not the center of the world, and moves, and that I must not hold, defend, or teach in any way whatsoever, verbally or in writing, the said doctrine; and after it had been notified to me that the said doctrine was contrary to Holy Scripture, I wrote and printed a book in which I discuss this doctrine already condemned, and adduce arguments of great cogency in its favor, without presenting any solution of these; and for this cause I have been pronounced by the Holy Office to be vehemently suspected of heresy; that is to say, of having held and believed that the sun is the center of the world and immovable, and that the earth is not the center and moves.

"Therefore, desiring to remove from the minds of your eminences, and of all faithful Christians, this strong suspicion, reasonably conceived against me, with sincere heart and unfeigned faith I abjure, curse and detest the aforesaid errors and heresies, and generally every other error and sect whatsoever contrary to the said Holy Church; and I swear that in future I will never again say or assert, verbally or in writing, anything that might furnish occasion for a similar suspicion regarding me; but that should I know any heretic, or person suspected of heresy, I will denounce him to this Holy Office, or to the inquisitor and ordinary of the place where I may be. Further, I swear and promise to fulfill and observe in their integrity all penances that have been, or that shall be, imposed upon me by this Holy Office. And, in the event of my contravening (which God forbid) any of these my promises, protestations and oaths, I submit myself to all the pains and penalties imposed and promulgated in the sacred canons and other constitutions, general and particular, against such delinquents. So help me God, and these his holy Gospels, which I touch with my hands.

"I, the said Galileo Galilei, have abjured, sworn, promised and bound myself as above; and in witness of the truth thereof I have with my own hand subscribed the present document of my abjuration and recited it word for word at Rome, in the Convent of Minerva, this 22d day of June, 1633.

"I, Galileo Galilei, have adjured as above with my own hand."

According to tradition, when Galileo rose he stamped on the ground and said "E pur si muove" (and it does move, for all that). If he did pronounce these words he, without doubt, did it mentally, as he was before enemies who were too cruel to have pardoned it. But this is of no importance; the voice of the human race, by saying it for him, will avenge him eternally.

The judges declared themselves satisfied with this retraction, but still wishing to continue their vengeance, they pronounced the following sentence against him:

"Whereas you, Galileo, son of the late Vincenzo Galilei, Florentine, aged 70 years, were in the year 1615 denounced to this Holy Office for holding as true the false doctrine taught by many, that the sun is the center of the world and immovable, and that the earth moves, and also with a diurnal motion; for having disciples to whom you taught the same doctrine; for holding correspondence with certain mathematicians of Germany concerning the same; for having printed certain letters, entitled 'On the Solar Spots,' wherein you developed the same doctrine as true; and for replying to the objections from the Holy Scriptures, which from time to time were urged against it, by glossing the said Scriptures according to your own meaning; and whereas, there was thereupon produced the copy of a document in the form of a letter, purporting to be written by you to one formerly your disciple, and in this divers propositions are set forth, following the hypotheses of Copernicus, which are contrary to the true sense and authority of Holy Scripture:

"This holy tribunal being therefore desirous of proceeding against the disorder and mischief thence resulting, which went on increasing to the prejudice of the holy faith, by command of his Holiness and of the most eminent lords cardinals of this supreme and universal inquisition, the two propositions of the stability of the sun and the motion of the earth were by the theological 'qualifiers' qualified as follows:

"The proposition that the sun is the center of the world and does not move from its place is absurd and false philosophically and formally heretical, because it is expressly contrary to the Holy Scripture.

"The proposition that the earth is not the center of the world and immovable, but that it moves, and also with a diurnal motion, is equally absurd and false philosophically, and theologically considered, at least erroneous in faith."

According to these premises, worthy indeed of those who gave such great proof of their ignorance, it was further stated that Galileo had incurred all the censures and penances pronounced by the sacred canons, concluding the sentence thus:

"And in order that this, your grave and pernicious error and transgression, may not remain altogether unpunished, and that you may be more cautious for the future, and an example to others, that they may abstain from similar delinquencies, we ordain that the book of the 'Dialogues of Galileo Galilei' be prohibited by public edict.

"We condemn you to the formal prison of this Holy Office during our pleasure, and by way of salutary penance, we enjoin that for three years to come you repeat, once a week, the seven penitential Psalms.

"Reserving to ourselves full liberty to moderate, commute, or take off, in whole or in part, the aforesaid penalties and penance."

Pope Benedict XIV. annulled this absurd sentence many years after. The partisans of the ancient idea of the immobility and stability of the earth were disappearing little by little, and now the theory of the movement of our globe is taught everywhere, even in Rome.

Galileo was the vigorous athlete who succeeded in giving the human mind a new method of thought. Before him everything was based on the *a priori* and deductive reasoning; facts were considered secondary matters that must be turned and twisted until they were made to adapt themselves to the form conceived for them by thought. Galileo overturned this miserable and barren order of things; he saw in facts the true and unchangeable masters of the thinker, and instead of reducing facts to be slaves of the imagination, he took them as infallible guides in his studies.

He showed that facts, gathered by constant observation, can be dominated by mental labor; that if the imagination does not precede observation, but follows it, it will always find a way to exercise its creative power on nature; that by work combined with observation, thought can raise marvelous edifices, simple in themselves, complete as nature itself in its manifestations.

The prolific principles initiated by Galileo inspired the men of science who succeeded him, and to these principles is due the great modern scientific movement which creates wonder by the miracles of its discoveries and the genius of its technical applications.

Thus Galileo is the true initiator of modern science; he did not present himself between two centuries armed against one another, to judge their discords; but surrounded by a halo of most enviable glory, he appears between two scientific eras, the old and the new. His figure towers above his contemporaries, and no progress of his successors can diminish his splendor. He is the first truly modern man.

The engravings referring to the life of this great man that we publish in the present number deserve special explanation.

The first is one of the best portraits of Galileo, painted by Giulio Substermans, and is preserved in the Galeria de los Oficios de Florencia. Here we have almost a full face; he is uncovered, his eyes are thoughtful, and his forehead, as the poet said, is engraved by great thoughts. Giulio Substermans was one of the Flemish painters who were enamored of the beautiful Italian sky; he was born in Antwerp, in 1597, and when still young went to Florence, where he was well received by Cosme II. He became famous, and died in 1681.

Among the many mementoes of the illustrious physicist in Pisa is the house in which he was born on February 18, 1564, as is stated by the inscription placed on it in 1864. Hanging from the center of the cupola of the cathedral in this city is the very lamp to which we referred, and which was made by Vincenzo Possenti; it is now known as the "lamp of Galileo."

The house in Padua in which he lived and taught his pupils is still in existence.

The facade of the "Bo" represented in another engraving is no other than that of the ancient University of Padua. Where this edifice now stands was, in the thirteenth century, the Carrera Palace, with two towers. In 1364 the palace was converted into an inn, with the sign of an ox (*bo* in the Venetian dialect). In 1492 it was taken by the government of the Venetian republic to be used by the university professors, who were then scattered in various parts of Padua. Where the stalls had been, lecture halls were built. The old name "Hospitium Bovis" was replaced by "Sapientia;" but every one continued to call both the edifice and the university "the *Bo*."

A relic of Galileo is preserved in the physical room of this university; it is the fifth lumbar vertebra of this great man. The celebrated physician and mathematician Antonio Cocchi, being charged with the removal of the bones of Galileo from the cloister of the church of Santa Croce, kept this vertebra and afterward bequeathed it to his son Raimundo. The precious relic then passed from hand to hand until finally Dr. Thiene gave it, in 1823, to the Atheneum of Padua. There is no doubt of its authenticity, for it is proved by documents.

The statue of the Italian physicist shown in our engraving was erected in the Prato del Valle in the last century. It is the work of the Italian sculptor, P. Danicletti, who represented Galileo contemplating the sun with his right hand raised, while his left hand grasps a telescope. Outside of the wall of Florence still stands the *Torre del Gallo*, celebrated as having been inhabited by Galileo, but especially because it served him as an astronomical observatory. This tower, which is now the property of Paolo Galletti, was restored in 1877.

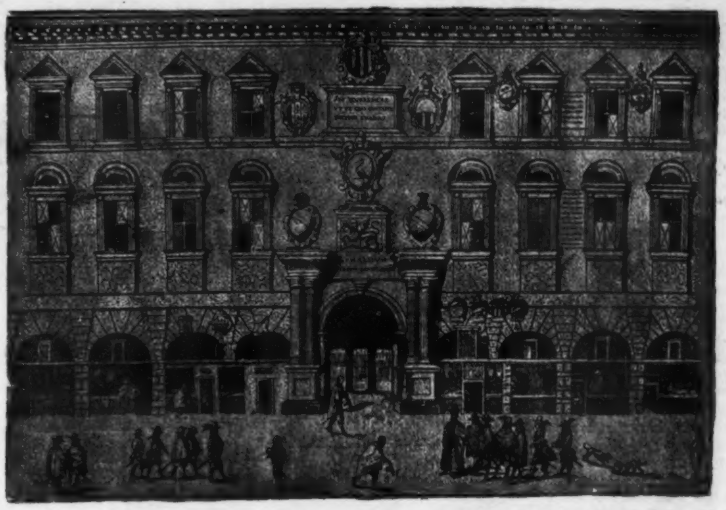
The Galileo Museum in this tower contains manuscripts by Galileo or referring to him. We give *fac similes* of two of them; one is a letter from the Inquisitor of Florence to the Archbishop Nicolini, treating of the sentence pronounced against him; the other is an autograph of Galileo, that reveals the troubles with which this eminent man had to struggle.

Finally, the monument to Galileo erected in the Church of Santa Croce is the work of the sculptor Giuseppe Signorini, who died in 1821.

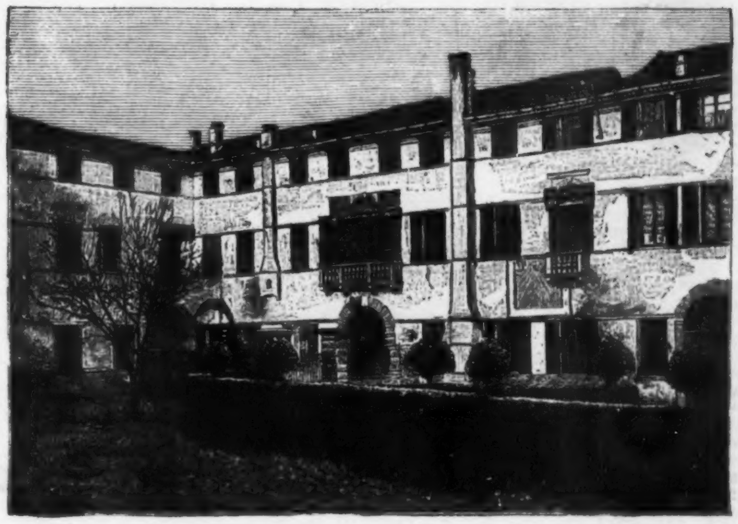
For the extract from the sentence and Galileo's abjuration, we are indebted to Mrs. George Sturge's translation of Von Gebler's "*Galileo Galilei and the Roman Curia*," and for the rest of the article and the illustrations to our esteemed contemporary *La Ilustracion Artistica*.

## THE GALILEO CELEBRATION AT PADUA.

THE celebration of the three hundredth anniversary of the day on which Galileo began his labors as a professor at the University of Padua was even more successful than had been anticipated. Its success was in every way worthy of the large number of scientific men who assembled to do honor to Galileo's memory and of the great institution with which, as it remem-



FACADE OF THE "BO," IN THE TIME OF GALILEO.
(From the "Gymnasium Patavinum" of I. F. Tomasini.)



HOUSE IN WHICH GALILEO LIVED IN PADUA.

THE CELEBRATED "LAMP OF GALILEO," IN THE CATHEDRAL OF PISA—WORK OF VINCENZO POSSENTI.

THE TORRE DEL GALLO, NEAR FLORENCE, IN WHICH GALILEO LIVED—OWNED BY COUNT PAOLO GALLETTI.

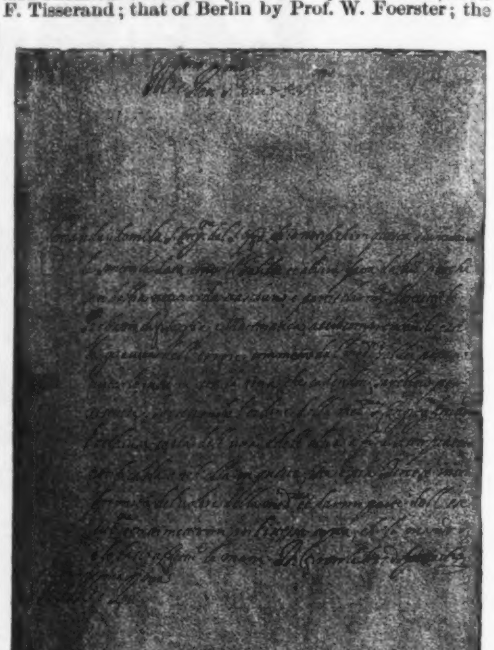
HOUSE IN WHICH GALILEO WAS BORN, NEAR THE FLORENTINE GATE, PISA.

bers with veneration and pride, he was so intimately associated.

On December 6 the rector, Prof. C. J. Ferraris, received in one of the courts of the old University, adorned everywhere with portraits of the most illustrious professors, delegates from the universities, the polytechnic schools, and Italian and foreign academies, amounting to nearly a hundred, and among them many of those who shed most luster on contemporary science. The University of Cambridge was represented by Prof. George Howard Darwin, F.R.S., who also represented the Royal Society, as Mr. Norman Lockyer, its delegate, had been prevented from attending. The University of Oxford by Prof. E. J. Stone; the Royal College of Physicians, London, by Sir Joseph Fayrer, F.R.S.; the Chemical Society and British Association by Prof. Ludwig Mond, F.R.S.; the Harvard University, Cambridge, U.S.A., by Prof. William James, and the Princeton University by Prof. Allan Marquand; the University of Lund by R. A. V. Holmgren; the Astronomical Observatory of Paris by its director, Prof. F. Tisserand; that of Berlin by Prof. W. Foerster; the Polytechnic Schools of Berlin, Karlsruhe, Monaco, Brunswick, Stuttgart, by Profs. Lampe, Keller, Sohncke, Blasing, Lemcke; the University of Gottingen by Prof. Voigt; that of Budapest by Prof. Lanczy; that of Dorpat by Prof. Schmourlo; that of Lausanne by its rector, Prof. Favey; the Academy of Paris by Prof. Gariel; the Faculty of Letters at Grenoble by Prof. De Croyals; the General Council of the Faculty at Nancy by Prof. Molk, etc. There were also delegates from the towns of Florence, Pisa, Venice, and representatives from the foremost Italian universities, academies, and technical schools.

The great academical celebration took place on December 7 in the large hall of the University, in the presence of the Hon. Ferdinando Martini, Minister of Public Instruction, who represented the King of Italy. The ceremony was begun with a discourse prepared for the occasion by the rector magnifico, and devoted principally to a cordial expression of thanks to the king and to the minister who represented him; to the

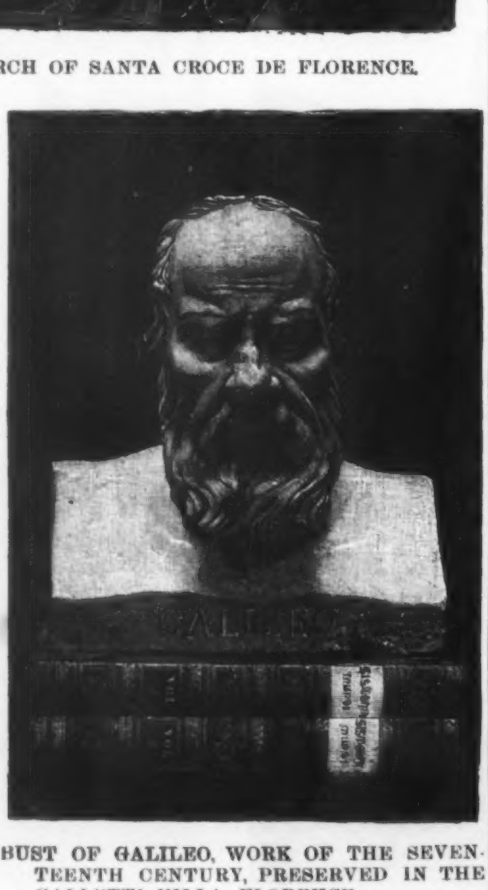
MONUMENT TO GALILEO IN THE CHURCH OF SANTA CROCE DE FLORENCE.



LETTER FROM THE INQUISITOR OF FLORENCE TO THE ARCHBISHOP NICOLINI IN REGARD TO THE SENTENCE OF GALILEO.

FIFTH LUMBAR VERTEBRA FROM GALILEO'S SKELETON, PRESERVED IN THE DEPARTMENT OF PHYSICS IN THE UNIVERSITY OF PADUA.

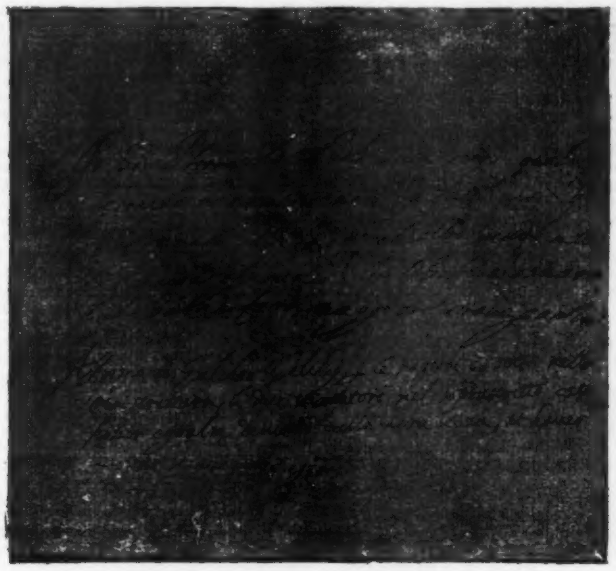
MONUMENT TO GALILEO IN THE PRATO DELLA VALLE, IN PADUA.



BUST OF GALILEO, WORK OF THE SEVENTEENTH CENTURY, PRESERVED IN THE GALLETTI VILLA, FLORENCE.

foreign and Italian delegates; and to the ladies of Padua, who had given the University a most beautiful banner, on which were various emblems indicating the history of the University, the genealogical tree of the Galileo family, and the ancient inscription above the door of the University—*Gymnasium omnium disciplinarum.*

Next came the commemoration of Galileo by Prof. Antonio Favaro, who has for nearly fifteen years devoted himself almost exclusively to the study of the life and works of Galileo, and to whom was confided by the government the care of the national edition of the philosopher's works, under the auspices of the King of Italy. The orator kept his discourse within the limits marked out for him, speaking chiefly of Galileo at Padua. Constrained to leave the University of Pisa, Galileo had been welcomed in that of Padua, where he found the "natural home of his mind," a "theater worthy of his talents." The conditions at Padua at that time were eminently favorable to Galileo's work, for the Venetian senate granted the lecturers the utmost liberty, and experimental methods, which could not be learned from books, had been practiced at the University for more than a century. Galileo had many opportunities for the development of his genius, both in the lecture room and in the home in the preparation of scientific publications, and in the workshops of scientific instrument makers both in Padua and Venice. To Venice he frequently went, attracted thither by the means it afforded him for study; by that grand arsenal which had already been sung by Dante, and which in his reputed dialogues is spoken of by Galileo with admiration; but above all by the advantages he derived from scientific intercourse with eminent men who resided in the dominion. The culminating point of the discourse was naturally reached when the orator had to deal with the invention of the telescope, and with the astronomical discoveries made by means of it, the immediate result of which was the recall of Galileo to Tuscany. This did not aid Galileo in his glorious career, or help to protect him from the attacks which were for a long time made on him by invidious adversaries. Even some of his own servants changed at once to implacable and dangerous enemies, and at last he was involved in all the miseries which sprang from the memorable lawsuit. This led the orator to recall the fact that, when the clouds assumed their most threatening aspect, the Venetian republic, forgetting with real magnanimity whatever resentment it might have felt at Galileo's abandonment of his chair at Padua, offered to reappoint him, and to print at Venice the work which had brought upon him so much trouble. He said also that a pleasant memory of Padua must have passed through the mind of the prisoner of the Holy Office, when there came to him his only comfort, the message from the favorite of his childhood, the nun who in Padua had tenderly cared for him during the first ten years of his youth.



AN AUTOGRAPH OF GALILEO.

THE GALILEO MUSEUM IN THE TORRE DEL GALLO, NOW THE GALLETTI VILLA.

COURT OF THE TORRE DEL GALLO, NEAR FLORENCE, NOW THE GALLETTI VILLA.

After Prof. Favaro's oration discourses were delivered by the foreign delegates, Holmgren, Fayrer, Darwin, Tisserand, Lampe, Keller, Foerster, Sohncke, Blasing, Lemcke, Farey, Lanczy, Schmourlo, and by Italian delegates, Nardi-Dei, Mantovani-Orsetti, and Del Lungo. Then followed the conferring of University honors, of which seven had been set apart by the council for seven men of science, one for each nation, all distinguished for their devotion to the studies in which Galileo excelled, viz., Schiaparelli, Helmholtz, Thomson, Newcomb, Tisserand, Bredichir, and Gylden. The degree of philosophy and letters was given to the Minister Martini; of natural philosophy, and philosophy and letters, to the leading delegates. The ceremony was closed by the inauguration of a commemorative tablet in the large hall.

Of the other festivals connected with the celebration it would be out of place to speak here, and it will be better to add a list of the publications which have been issued on the occasion. The oration read in the great hall by Prof. Favaro has been published, with the addition of twenty-five facsimiles of documents containing the various decrees of the senate concerning Galileo, the date of the early prelections given by him at regular intervals, several autographic records of Galileo, chosen in order to give a more exact idea of what are the most precious materials for his biography, the frontispieces of the various publications issued by Galileo, or relating to the time of his sojourn in Padua, the geometric and military compass, the writing presenting the telescope to the Doge, and the first observations of the satellites of Jupiter. A portrait of the great philosopher, from a painting which represents him at the age of forty, taken in 1604, is prefixed.

By favor of the University there have also been published two other works, one containing all the notices of the studies at Padua in 1592, the other proving which was the house inhabited by Galileo and the place in which he made his astronomical observations. The ancient Academy of Padua, among whose founders Galileo is numbered, has issued a publication in which are collected several works dedicated to his memory; and the students of the University have sought to perpetuate the remembrance of this festival by the publication of a "unique number," bringing together all the documents relating to the sojourn of Galileo in Padua collected from all quarters. These publications will serve as suitable memorials of a great and most interesting celebration.—*Antonio Favaro, in Nature.*

## VEGETABLE WAX.

IN an article on vegetable wax (*Zeitschrift fur Nahrungsmittel Unters, Hygiene, u. Waarenkunde*, 1892, p. 303) Herr C. Buhrer states that about 1,500,000 lb. were exported in 1889 from West China, Japan, and tropical America. There are ten distinct kinds (including vegetable tallow), viz., carnauba, pela or Chinese wax, sumac or Japan wax, kaga and Ibota wax, stillingia or Chinese vegetable tallow, myrica wax, orizaba wax, stocklack wax, and Bahia wax. Chinese insect wax comes from S'ze-Chuen and Koui-Chu, and is the product of a tree with opposite thick oval leaves and small white flowers, known at Kew as *Ligustrum lucidum.* With the commencement of spring the branches are covered with numerous pea-shaped scales, inhabited by the larvæ of the wax insect, *Coccus pela.* The larvæ are gathered, taken to Chia-Ting, and there hung beneath the leaves of a different tree, probably *Fraxinus chinensis.* The perfect insect makes its appearance in about fourteen days; the female forms capsules for the accommodation of its offspring, the male white wax which appears on the underside of the leaves, and, at first, resembles fresh fallen snow. When this coating has attained a considerable thickness it is taken off and boiled to destroy the insects. Every pound of larvæ produces about 4 or 5 lb. of wax, which

is worth in Shanghai about one dollar per kilogramme. Kaga wax is obtained from *Cinnamomum pedunculatum*, and is softer than Japan wax, but is not exported, nor is the fine white Ibota wax obtained from *Ligustrum Ibotu*. Japan wax is obtained from the kernels of the fruit of *Rhus succedanea, vernicifera*, and *sylvestris*. Its preparation is one of the principal industries of Kinsin, the best kind coming from the province of Hizan.

## SIBLEY COLLEGE LECTURES.—1892-93.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

### THE GENESIS AND EXODUS OF STEAM.

By GEORGE H. BABCOCK, of New York.

IN the beginning, before time was born, when creative energy first began to be exerted, there emanated from Deity himself—because there was nothing else from which to create it—a primal form of matter, the first created thing. What it was we have not been told, but if we suppose that the Creator has followed from the first the plan of evolving the complex from the simple, it is probable that it was that thing which is most elemental in its composition and characteristics. From this point of view it is not improbable that the first thing made was hydrogen, the least ponderable of all substances, believed to be the simplest in its atomic construction, for which reason it has been chosen by scientists as the unit of the chemical scale, and looked upon by many as the basal element from which all others have been made. But, whether it be the primal creation or the basal element, it is a fact that hydrogen conserves in a greater degree than anything else known to us that energy which, itself a divine essence, is manifest to us under different forms which we call light, heat, electricity and force.

Among the earliest created things must also have been oxygen, for it forms a very large part of most substances found in nature. This element is remarkable in many ways, but mostly in that it possesses an affinity for every other known element. Is it therefore too much to say that it symbolizes another great attribute of its Creator—infinite, universal love?

It was these two elements which the All-wise chose to unite, to form that which was to become the greatest physical blessing to the being whom he purposed to create in his own image and place upon the earth in the then future ages.

And so oxygen and hydrogen were married, and in their union brought forth steam in its highest state of energy, ready for its mission in the world, and when, in fulfilling that mission, it had imparted very much of its energy to the things around it, it condensed and became water, and when this had further given of its heat to things colder than itself, it became ice, and so in its triune forms of steam, water and ice, this mineral has gone on from that day to this performing some of the most important and stupendous works in the preparing of this earth for the abode of man. As steam it has shaken and riven the earth, opened and erupted volcanoes, dissolved many other minerals, and deposited them in form or place where they can be made of use, besides having a large share in pushing forward the early vegetation which went to form our coal fields. As water it has fertilized the earth, denuded the surface in many places, and deposited its spoils on others as beds of clay and other alluvial matters; served as a medium for stratifying and even forming many of our rocks, and supported hordes of aquatic animals, whose remains are to-day a prominent part of the earth on which we live. As ice it has had no less part in shaping the face of the earth, digging down mountains, plowing out valleys and transporting rocks to places far distant from their original homes, building up hills and plains innumerable with glacial drift, and disintegrating many of the softer rocks to form the soil in which vegetation thrives. And, since the advent of man upon the earth, this earliest of the compounds has proved itself to be his most obedient and useful servant, as well as his constant friend.

Perhaps you are startled to hear steam classed as a mineral, but if we accept the evidence of science that hydrogen is a metal, then steam and water are a metallic oxide, and as truly mineral as are oxide of iron in iron ore, or oxide of alumina in the ruby and emerald.

We imitate this original genesis of steam in a small way in the oxy-hydrogen flame, and in fact in all our gas lights, for a part of our illuminating gas is hydrogen. The same process is also taking place on a prodigious scale in nature, particularly in the sun, for the telescope and the spectroscope have revealed to us enormous flames of hydrogen, frequently shooting thousands of miles beyond the photosphere of the sun, which cannot be aught else than the festive dance at the nuptials of these two parents of steam.

If to produce one pound of steam or water we mingle $\frac{1}{9}$ of a pound of hydrogen with $\frac{8}{9}$ of a pound of oxygen, and ignite them by a spark of electricity or otherwise, a great expansion takes place with a violent explosion, and enough heat is liberated to have melted 20 pounds of steel, or 70 pounds of gold, or 350 pounds of lead, if it could all have been imparted thereto; and enough, if it were turned into dynamic energy, to have lifted 2,600 tons one foot high, or to have exerted two and one-half horse power for an hour. The temperature produced, if we suppose the steam to retain its specific heat and the whole quantity to be burned at once, would be 12,000° F., or about that wished for by the exasperated Nebuchadnezzar when he ordered the furnace for the reception of his recalcitrant subjects to be heated seven times hotter than it was wont to be heated. It is believed, however, to be impossible ever to attain that excessive temperature by combustion, because long before it is reached, the action of dissociation takes place, and the gases refuse to burn further until some of the heat has been radiated or otherwise disposed of. Nevertheless the oxy-hydrogen flame is still the hottest thing known to us except the electric spark, and is capable of fusing many of the most refractory substances. When it is caused to heat lime or magnesia to incandescence it gives us the well-known calcium light, the most powerful artificial light known—except that of the electric arc.

But to return to our pound of steam. We found it at its birth endowed with an almost inconceivable energy, more than that developed by the combination of the same quantity of any other elements. This energy or heat it readily imparts to surrounding objects, and it is therefore employed by man to melt, solder, sublimate, heat, or otherwise perform work for him. When it has given off enough heat to have raised 37 pounds of water from the freezing to the boiling point, it will itself become water, and if we still go on reducing its temperature by absorbing its heat, until it has given off enough more to heat 320 other pounds of water one degree, or have melted 2¼ pounds of ice, it will have become solid ice itself; but even then it will have retained a quantity of heat, so much so that an amount equal to ¾ of that given off since it first became water would have to be extracted before it could arrive at the condition of absolute cold.

But we are more interested as a matter of practice in the regenerating of steam for our use, for even if we found it in sufficient abundance in nature, as in geysers and hot springs, it would scarcely be capable of being harnessed for our service like that which is made in boilers. Water is the most abundant thing in nature. Hence we have no lack of material, and all that is necessary is to restore to it so much of the heat energy it gave up in becoming water as is necessary to turn it again into steam, and bring it to the condition in which it can best work in the harness which we have prepared for it.

And for this purpose we find another bountiful provision of kind nature, in the vast accumulations of stored energy, which we call fuel. How much of this energy thus stored for our use is that which was given off by the primal steam when it became water, we may not know, but that many of our coal fields were laid down while the infant earth was enjoying its steam bath in those ages of hot humidity which preceded the advent of life upon the globe, is doubtless true. However, we mine these stores of coal and put a part of their energy into a portion of water, and so transform it, and say we are making steam, as though it were an original creation.

Let us watch the process. We have say one pound of water, the same quantity that we have just seen made by original synthesis, and we put it in the bottom of a vessel in which we have fitted a perfectly tight and frictionless piston. To the bottom of this vessel we apply our heat, assuming that the vessel itself has neither specific heat nor power of radiation, whereby we are enabled to apply our heat to the water without interference or losses. We start with the water at the temperature of melting ice, 32° Fah., and occupying a certain cubic space, which for our purpose we may consider as a unit. As heat is added its temperature rises at the rate of one degree for each thermal unit, but for a time this produces no expansion. By a special provision of the beneficent Creator, water does not follow the almost universal law of expansion by heat, until it arrives at about 8° above the freezing point, so that when our great bodies of water, in cooling off during the winter months, have arrived at that point, the cold water no longer sinks, but remains on top to freeze and form a crust of ice, which preserves from extinction the animal life within the depths beneath. At about 40° the water is at its greatest density, and from that time on it will be found to expand gradually as it increases in temperature, until it has arrived at 212°, by the addition of 180⅓ thermal units, when, if our piston be supposed to be without weight, and to be held down only by the pressure of the atmosphere at the level of the sea, it will have come to what is known as the "boiling point." This boiling point varies with every variation of pressure. Its characteristic is that, when at this point, the water is incapable of becoming any hotter, and every addition of heat thereafter, however small it may be, converts a portion into steam; in other words, the water has all the heat it can hold—as water—at that pressure. Our French friends have therefore named this the "point of saturation," and water in this condition they call "saturated." It is a good term, and deserves to be adopted by us.

Our pound of water, now at 212°, has increased slightly in bulk, so that it occupies about 4 per cent. more space than before, and it has therefore forced up the piston to that extent, and performed an amount of work equal to the distance into the pressure, or, say, the equivalent of one pound raised seventeen inches, and heat energy to that value has disappeared. The heat we have put into our pound of water up to this point has been employed in three ways—first, doing mechanical work in raising the piston; second, overcoming the internal resistance of the water to the separation of the molecules causing expansion; and third, in setting up a more rapid oscillation among the atoms, which we call raising the temperature. The first is so small as to be scarcely appreciable, being less than one one-hundred-thousandth. The second is considerable, and has been estimated to be about 60 per cent. of the whole, while the third is the remaining portion, say 40 per cent., or 72 thermal units.

Now, however, at the point of saturation, an entirely new law comes into force, and the addition of more heat, so long as any water remains, does not raise the temperature any higher, but every unit of heat so added converts a small portion of the water—a little over one one-thousandth part—into steam, having a bulk 1,622 times greater than the water from which it is made, but the same temperature. Here one unit of heat has raised the piston 7,800 times more than the same quantity of heat had done before, and of course accomplished that much more mechanical work, or about the equivalent of 60 pounds raised one foot high. But, as a unit of heat, when all converted into mechanical work, is equal to 778 pounds raised one foot high, only about 8 per cent. of our heat unit has been used up in overcoming external resistance, and the balance has been employed in separating the molecules, overcoming their attraction for each other while assuming their new relations. We may in this way add 966 heat units to our pound of water, each one accomplishing the result just described, when it will be found that every particle of the pound of water has become steam at atmospheric pressure. But the whole of these 966 units have produced no effect whatever upon the thermometer, whence this heat has been termed "latent," which means that it has been devoted to other departments in the business of raising steam. It is not lost, however, any more than the force you exert in raising a weight or in winding up a spring is lost. It is simply stored ready for use. That portion which was spent in raising the piston against atmospheric pressure is given back when the piston is allowed to fall, and that used in the internal work of expansion is given back either as heat or work when the molecules again come nearer each other to form water, just the same as the watch spring gives back the force you exerted in winding it up.

The action we have thus described is that which takes place every time you boil water in a tea kettle or other open vessel, the atmospheric air taking the place of the piston; but the action in a steam boiler is somewhat different.

If we had placed our pound of water in a close vessel of infinite resistance to rupture, and just large enough to hold it, we could have heated it to any extent without making steam. If we suppose the envelope to have the same coefficient of expansion as the water, and the water to retain the same specific heat as at low temperatures, it will be found that when there has been added the same quantity of heat as was required before to make it all into steam, instead of indicating 212 deg. in the thermometer as before, it will now show nearly 1,200 deg., or be red hot, at which high temperature it would exert a pressure of about 20,000 pounds per square inch, and if permitted to expand against atmospheric pressure only, it will all become steam at 212 deg. as before.

But what we call a steam boiler, though it does not boil steam, but rather generates steam by boiling water, is a close vessel of sufficient strength to stand the pressure we desire to carry, and somewhat larger than the water we put into it. Let us suppose we have such a vessel of *one cubic foot* capacity, and put into it one pound of water, as before, at 32 deg. As we add heat up to the point of saturation, we perceive no difference from the former conditions, but at that point another set of conditions come into play. As we go on adding heat, part of the water is vaporized, as before, but, being prevented by the envelope from expanding, it crowds the available space, and the pressure upon the surface of the water is increased, raising the point of saturation gradually, so that not all the heat added now is employed to vaporize the water, a part going to increase the temperature of the fluid up to the new point of saturation. But as the steam is not allowed to expand as much, a less amount of heat is expended in that work, and none at all is required for external work, so that the proportion of the water evaporated for each unit of heat added remains nearly the same, decreasing very slightly. When, therefore, we have added the 1146 heat units which before, under one atmosphere of pressure, were sufficient to heat the fluid and evaporate the whole of the pound, the pressure will have risen in our vessel to nearly thirty atmospheres, and a small amount, say 10 per cent., of the water will still be present as water at the temperature of saturation normal to that pressure, or 450 deg. If now we go on adding heat until we have added 80 units more, we will find all the water evaporated and have a cubic foot of steam at a pressure of 475 pounds per square inch above a vacuum.

If, however, instead of carrying the pressure to this high point we had added only sufficient heat to raise the pressure to 100 pounds per square inch absolute, we should then have evaporated a little over ¼ of our pound of water, and the remainder would have been at 327½ deg., the point of saturation at that pressure. And if now we begin to draw off the steam for use, adding heat as required to keep up the pressure, we shall have the conditions of the ordinary steam boilers in which steam is generated for all the purposes required for the uses of mankind. No matter what the size of the boiler, or what is its construction, or the pressure carried, the principles which underlie the generation of steam within it are the same, and are illustrated in the small boiler we have supposed. Many differences may exist as to their advantageous application and the adaptation of the boiler to the best realization of the value of the heat applied, but these questions do not belong to the present discussion.

Having now considered at length the making of steam, let us look into the question of what becomes of it. It is not one of the things made to keep. It will not, like gold or the pyramids of Egypt, remain unchanged for ages. Its life is as evanescent as a cloud. It is made to-day; to-morrow, nay, perhaps another moment, and it is not. Whither does it go, and what is the nature of its taking off?

There are three ways in which steam may cease to exist. 1st. It may convert its heat into work, and die in performing the task set it by its master. 2d. It may give up its heat to another body, having done which it must resume the condition of water. 3d. It may become dissolved in the air, and merge itself into that benefactor as well as tormenter of our race, "general humidity." It is, however, in the first two modes of quitting existence that it makes itself especially useful to man.

This transformation of heat into dynamic as well as into other forms of energy, and *vice versa* each into any other, is one of those strange things in nature which we have only begun to comprehend. That a blow of the flint upon a piece of steel, or the friction of one piece of wood upon another, would produce heat and fire was known from the earliest days, but that the heat produced was the direct result and equivalent of the force exerted was only discovered at a comparatively recent date. And still more recently did we come to understand that for every force exerted, either by man or by animals, or in any of the processes of nature, an equivalent quantity of heat, or some other form of energy, disappears. The changing of heat into light is well illustrated by the incandescence of a piece of white-hot iron or a burning coal into electricity by the thermic pile. Work, or force in action, is turned into electricity when we make the cat's fur sparkle by stroking it, or produce a shock by scuffling along the carpet, as well as by the steam engine driving a dynamo.

Electricity is changed to work through the electric motor, to heat in the incandescent filament of our glow lamps and in the electric welding process, into light directly in the Aurora Borealis and the Geissler tubes. Our electric lighting, however, is done through the intermediary instrumentality of heat. We first set heat loose from its prison in coal, and after transferring it to steam, transform a part of it by a steam

engine into dynamic energy, then change this into electricity, that into heat, and the heat into light. When we have mastered the methods of nature in the glowworm and firefly, we shall look back upon our present methods of lighting as crude indeed.

This is wandering from our subject, but it may lead us better to understand why steam gives up its energy and life when it is set to performing work.

As we have already seen, water in a state of saturation contains all the heat it can hold at that pressure. On the contrary, saturated steam contains the least amount of heat it can hold at that pressure, and the instant any of its heat, no matter how little, is subtracted, or turned into another form of energy, a corresponding part of the steam is condensed into water. When we had our pound of water heated red hot, and at a pressure of 20,000 lb. per square inch, if we had loaded it by a piston to that pressure, gradually reducing the load as it expanded and the pressure grew less, until it had been brought to atmospheric pressure, we should have found that it had exerted about half a million foot pounds of work, and that to cause it all to become steam at atmospheric pressure under those conditions, it would have been necessary to add about 690 heat units more than were necessary when it expanded all into steam without doing work, that amount of heat having been converted into the work done; or, in other words, if we had allowed it to expand doing the work, without receiving any additional heat, about half of it would have remained water at 212 deg.

In like manner, when we had a cubic foot of steam at 475 pounds total pressure, had we allowed it to expand in the same way as before, there would have been about 220,000 foot pounds of work done, and about one-quarter of the steam would have been condensed in the operation.

In the same manner, when the steam in the cylinder of an engine performs work by pushing the piston before it against a resistance, that work, necessitating a transformation of heat, robs the steam, so that at once a portion is condensed. In this way every hourly horse power of work done in an engine by saturated steam demands the condensation of about two and one-half pounds of that steam to supply the energy exerted. If this were all, our power would not be so very expensive, but alas! our machinery and methods are so very imperfect, and the conditions of the problem are such, that from five to twenty-five times that amount of steam, in addition, is compelled to pass through our engines to enable us to secure that amount of work; the balance, being discharged into the condenser or into the air, is of little or no further use to us.

The steam which goes into the cylinder of a steam engine may be divided into three portions, one of which is condensed in doing work, another and generally a larger portion is condensed in giving up its heat to the walls of the cylinder, to make up for heat wasted, both through these walls and from the evaporation of moisture on the surfaces during the exhaust. The third portion, much larger than either of the others, serves as a more or less necessary backing or companionship for the others. Thus when we had our pound of steam at 20,000 pounds pressure per square inch, we found that only half of it would be condensed in doing the work of expanding against resistance. Theoretically sixty per cent. could thus be utilized in a perfect steam engine without any preventable losses. When our pound of steam was at 475 pounds pressure, we found only 25 per cent. condensed in doing the work of expansion. In the best quadruple expansion engines of this day the proportion is a little less than one-fifth; in the best non-condensing engines it is one-tenth, while in the more wasteful it is sometimes only one-fortieth of the steam which is actually used in doing the work. So it comes to pass that every time one of our great ocean steamers, like the City of Paris, the Umbria, or the Teutonic, crosses the ocean, some thirty-five hundred *tons* of steam gives up its life to furnish the energy which pushes the ship with its cargo through the water, while other seventeen or eighteen thousand tons, in inseparable companionship, yields up its heat to the surrounding ocean, and takes again the form of water.

We have in the United States about 4,000,000 horse power of steam engaged in manufacturing, very little of which runs less than 10 hours per day, and much of it 24 hours, so that we may assume 13 hours as a fair average. There are, also, 35,000 locomotives of perhaps 250 horse power each, running an average of 36,000 miles per year, which would require, say, six hours per day, which, with steamboats, etc., make an estimated average of 120,000,000 hourly horse power each day, so that not less than 150,000 tons of steam is condensed per day, or fifty million tons per year, in *doing work*, while at least eleven times as much more is compelled to keep it company and pass out of existence, mostly without further use. This calls for some 100,000,000 tons of coal, or the equivalent of other fuel—but this is not all that goes to make steam.

There is much steam used for heating, which never enters an engine. Two reasons may be given why steam is the best of all substances for this purpose; first, it will carry more heat for a given weight, and, second, when it has given up its heat it instantly drops out of the way to make room for another portion to deliver its heat at the same spot. In this it is in marked contrast to air or gases, which, at atmospheric pressure and the same temperature as steam of ten pounds, hold only 1-160 of the heat, and do not part with that readily, the cooled portion remaining in contact with the surface which absorbed its heat, and preventing the access of hotter portions thereto. Hence steam is very extensively used as a means of carrying heat from the place where it is convenient to generate it to the place where it is wanted for use, as in house heating, boiling, drying, etc. The amount used for this purpose is not easy to estimate. The New York Steam Company is the largest provider of steam for house heating, and it supplies during the colder months of the year about 8,000 tons of steam per day, or for the year, summer and winter, say 1,600,000 tons. It is roughly estimated that the amount used in the city of New York alone is 18,000,000 tons per year, and that there is used in the whole United States, say, 150,000,000 tons. Add to this that used for heating and boiling in various processes not counted in manufacturing, and we may safely say that a total of 200,000,000 tons would be within the truth. This will add another 30,000,000 tons to the coal account, making a total of 130,000,000 tons of coal or its equivalent used per annum for making steam. As the natural gas used during 1891 was equal to some 20,000,000 tons of coal, this, with the petroleum and wood used for fuel, would probably reduce the total coal used for making steam to about one-half the amount mined, which, in 1891, was 150,000,000 gross tons.

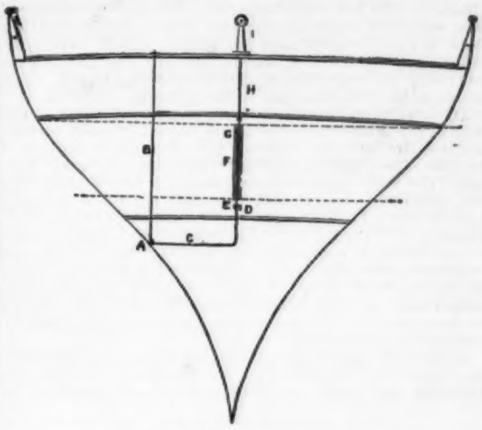
We now come to the third way in which steam makes its exodus, that of being dissipated in the atmosphere. Air at a temperature of 58 deg., which is near the average temperature of the earth, has an appetite for vapor which is not satisfied until it has drank in about one per cent. of its weight. The higher its temperature the greater its appetite, and the lower it goes in the thermometric scale, the less moisture it will hold. Thus at 128 deg. it is not satisfied with less than 10 per cent. of its own weight, while at 38 deg., ½ of one per cent. fills it to repletion. So when the teakettle is boiling over the hob, the rising steam is readily absorbed or dissolved by the air, and becomes invisible. And when the passing locomotive throws a cloud of steam into the atmosphere, it, too, soon disappears, as completely as if it never had existed, and, though the air is at a temperature at which steam, as steam, cannot exist under such a pressure, but becomes water, this vapor is uncondensed. It is only when the air becomes over-saturated, as by cooling it until the amount it contains is too great for its appetite, that this vapor takes on the visible form and becomes cloud or fog, and is precipitated in the form of rain. Nature in her own processes provides for a sufficient absorption of vapor by the air to produce the amount of rain needed, but the steam artificially generated and thrown into the air to be absorbed by it is in addition thereto, and to our modes of thinking is prodigious. One concern alone, the Carnegie Steel Company, with its different plants, throws into the air every hour not less than fifteen hundred tons of steam. We have already found that the steam passing through the engines in the United States approximates 600,000,000 tons per annum. Some of this is condensed in doing work, and some in condensing engines, but we are safe to conclude that, together with the steam from dye houses, evaporating kettles for sugar and salt making, and in culinary operations, not less than that amount of six hundred million tons is annually thrown into the air, to be absorbed thereby. Does this enormous quantity affect the amount of rainfall? It probably does, but the processes of Nature are on so grand a scale that even this inconceivable amount may sink into insignificance. Let us see: The annual rainfall east of the Rocky Mountains varies from 20 inches in a very few places to over 60 inches in others, with an average of not less than 36 inches. This amounts, in that territory, to some 9,000,000,000,000 tons, so that if all the steam made in the whole country were confined to this side of the Rocky Mountains, it could add not over $\frac{1}{150}$ of one per cent. to the total rainfall, or $\frac{1}{400}$ of an inch—not enough to furnish one evening dew. Thus grander are the operations of Nature's workhouse than the most ambitious of man's handiwork! It is not probable that, however much we may in future ages increase our steam plants, we shall ever be able to affect, even to a perceptible amount, the ample provisions Nature has made for her own purposes.

It is not infrequently said that electricity is soon to supersede steam, and that then it may be expected that steam will make its final exodus from the service of man. Is this likely to occur? At present electricity for nearly all purposes for which it is used is made by dynamos run by steam power, and the more electricity is employed under present conditions, the greater will be the demand for steam. But it is not outside the probabilities that man may in the future find out some way to convert the heat of combustion into electricity direct, without the intervention of a steam engine, and when that time comes, if come it does, we may well conceive that one of the uses of steam will be done away with. But there is little probability that there will ever be found a more efficient means than steam for conveying heat from place to place, for which its cargo capacity excels all other available substances, wherefore, even though it be released from the drudgery of making the wheels go round, this oldest servant of mankind will doubtless ever continue to serve him as a common carrier of that necessity of man's existence and prime element in his manufacturing processes: so that the genesis and exodus of steam will probably go on through future ages as it has since creation began.

## THE DRAUGHTOMETER.

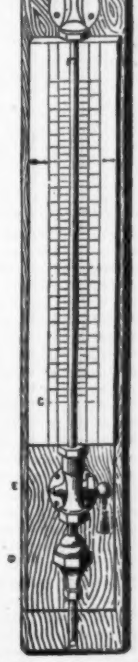
As an outcome of the stringent legislation as to overloading ships, consequent upon the Plimsoll agitation, the Board of Trade now require a degree of accuracy in loading which is scarcely possible in many cases, save by a method often much to the detriment of owners, *i. e.*, keeping on the "safe side," and probably losing twenty-five or fifty tons of freight. Cases have been frequent of late of shipmasters being fined, in sums ranging from £5 to £100 and costs, or in default, imprisonment, for allowing their vessels to be submerged from 1 in. to 4 in. beyond their load mark. In most of these cases the alleged overloading takes place under circumstances over which the master can scarcely be expected to have proper control. Even under the most favorable circumstances, the ordinary system of finding the draught by 6 in. figures on stem and stern posts—when these are not positively obscured by barges, lighters, quay walls, etc., is troublesome, tedious, and only approximately correct. When the water reaches the top or bottom of the figures referred to, the water line at any of the intermediate inches can only be estimated. These objections to this system are still more marked in cases where there is motion of surface water, such as is generally experienced in open roadsteads, and even in rivers under certain conditions. The results obtained under such conditions are, of course, not nearly accurate enough for the requirements of the Board of Trade. The provision, therefore, of a simple and inexpensive means by which the master can, with confidence, load his vessel to her marks, and the owner get the full benefit of the ship's carrying capacity, is a matter of considerable importance.

An apparatus designed to enable masters to load their vessels to a fraction of an inch, under all circumstances, has been invented by Captain J. B. Murray, of Glasgow, and is now being made and supplied by Messrs. Whyte Thomson & Co., nautical instrument makers, of Broomielaw, Glasgow. The apparatus in question, which the inventor names "The Draughtometer," is the outcome of a series of years' study of the subject, and of actual experience with an experimental apparatus on board ships which have been under Captain Murray's own command. The apparatus has received the approval of such eminent authorities as Lord Kelvin, Lord Ailsa, Mr. Herriot, of the Board of Trade; Mr. T. J. Dodd, of Lloyd's Register, etc.; and many ship masters and owners and their representatives who have seen it are impressed with the marked advantages to be derived from its use. The principle of the draughtometer is very simple—is almost analogous, in fact, to the ordinary water gauge on steam-boilers—but the details of its working, and the several




THE DRAUGHTOMETER.

purposes to which it may be made subservient on board ship, are skillfully thought out and arranged. It consists, as will be seen from our illustrations, essentially of a graduated vertical dial, or indicator, fixed in a convenient situation forward, and a similar dial fixed aft, on which are marked the feet and inches corresponding to the draught of the ship, and the tons of the ship's displacement due to such draughts, both in salt and in fresh water. Traversing the middle of this vertical graduated dial is a glass tube, which is practically a continuation of a vertical pipe, and its horizontal complement leading down the center line of the vessel and thence across to the ship's skin, where there is a sea cock, A, for the free admission of the water outside. This sea cock is situated near or a little below the level of the minimum load line, and consequently is free to operate throughout the whole range at varying draught due to loading or discharging at terminal ports, and of all intermediate variations between the minimum and maximum draughts during the course



DRAUGHTOMETER.

of the voyage. In the interior of the glass tube—which may range in height from 2 ft. to 6 ft. just as the range of draught and the fixed position of instruments in the ship may determine—is a float formed of aluminum, and so adjusted that the water in the tube, rising or falling, works the piston up or down, as the case may be, representing the loading or discharging. The surface of the water or the piston in the tube gives the draught. The arrow marks on the dial at K represent the maximum load water mark, which, in fixing the draughtometer forward and that aft, is made to precisely correspond with, or be in the same horizontal plane with, the official load mark on the outside of the ship. On each side of the draught scale is a graduated scale representing tons of ship's displacement, in salt and in fresh water, corresponding to the draughts—a

feature in itself of considerable utility to the intelligent shipmaster, as will afterward appear.

At the foot of the glass tube and dial is a regulating cock, E, and below it a brass valve, D, the uses of which will presently be explained. When a vessel is loading, the sea cock, A, is opened a little to allow the water to rise in the pipe slowly, as the ship goes down in the water. The regulating cock, E, is always kept full open, except when using same—in circumstances of excessive motion—in the manner about to be described. When there is motion of vessel, or of sea and vessel, causing any force of air or water through the pipe, this can be regulated by the sea cock; but any sudden force that may be felt is at once checked by the self-acting trap valve, D, which immediately closes, and will at once open again when that force is removed, and allow the water to rise or fall in the tube to the normal height, when the draught can at once be read. Should the draught be required when there is very considerable motion of vessel and sea, this can be found in the following manner. When the surface of the water reaches its highest point, the regulating cock is at once shut and the height noted. The cock is again opened, and when the surface reaches its lowest point it is again shut and the reading noted. The mean of the two readings is the draught required.

In most cases there is no insuperable difficulty in the way of the draughtometer being placed forward and aft against the forward collision and aft peak bulkhead in positions easily accessible for reading, at the same time that the scale graduations precisely correspond with the ordinary draught marks and with the midship load mark. In cases, however, where this is not practicable, or where a more convenient and rapid means of recording is desirable, the inventor has devised an ingenious supplementary indicator for fitting on deck in the same vertical line with the lower indicator just described. Indeed, bringing electric science to his aid, he has devised and patented a very useful supplementary electric recorder.

A marked advantage pertaining to the draughtometer consists in the fact that the graduated dial has the draught markings of feet, inches, and fractions of inches full size, and alongside corresponding to these the vessel's displacement in hundreds and tenths of hundreds of tons, both for salt and for fresh water. This is a decided improvement on the scale of draught and displacement as presently supplied by shipbuilders for the guidance of shipmasters. This latter, as is well known, embraces the whole depth of vessel, the feet and inch markings, in consequence, being represented on a much reduced scale; 1 in. usually representing 1 ft. The markings of tons displacement are also, in consequence, very minute, and any attempt to obtain an accurate reading to within ten or fifteen tons is the merest guess work. The draughtometer, only having to do with the range of draughts between the minimum and maximum load lines—which range is really all that shipmasters or owners are as a rule called upon to concern themselves with—enables the draught marks to be made full size and the displacement correspondingly open and easily noted. In this we think the inventor has shown shipbuilders how to make a decided improvement on the displacement scales they are called upon to supply to ship captains. Captain Murray instances as many as twelve distinct and practical advantages which may be derived from the draughtometer when fitted in any vessel. We can only briefly mention a few of these, *e. g.*, it provides a trustworthy means of finding the draught of a vessel by inspection of the lower gauge scale, or the deck indicator, preventing mistake in loading; used with the hydrometer, it will enable masters to know how to load their vessels to reach the center of disk in salt water; it will be of service in checking the daily consumption of coal at sea, and will also prove a reliable, impartial, and valuable check on the weight of bunker coal supplemented at foreign coaling stations; it will at once detect a serious leak, in event of collision, and indicate if the water is gaining, and the rate, also the effect of the pumps; it will enable engineers at sea to keep the vessel in any required trim, or to trim the vessel as may be required by the consumption of fuel from forward or aft, as the case may be, without resorting to the usual guess work, and it will enable masters to give pilots sound information *re* draught, and prevent loss of time and unnecessary anchoring, as all pilots know that the draught found in the usual way—allowing for consumption of coal, water, etc., from last port—is pure conjecture. In ports where the pilotage tariff is charged by draught of vessel, ¼ inch may prevent the ship being held liable for the higher tariff.

## THE AUSTRIAN TORPEDO CRUISER SATELLIT.

DURING the last days of December, 1892, the torpedo cruiser Satellit, designed by Mr. R. A. Ziese, and built by Mr. Schichau at Elbing for the Austrian government, and which we illustrate on this page, ran her full power trials at Pillau in the open sea. The weather was unfavorable, with a strong wind blowing and a heavy sea. The course taken was from Pillau Bay to Hekla Light, a distance of about 40 sea miles, and back, and the main speed actually reached between marks was 21·86 knots per hour; but as in consequence of the unfavorable circumstances a straight course could not be run, the real speed over the ground was rather over 22·5 knots, exceeding the contract speed by 1½ knots per hour. The ship was fully equipped, with all loads and fittings on board, and the coal bunkers were two-thirds full. The Satellit is a twin-screw boat of 800 tons displacement, her general appearance being well shown in Fig. 1, while Fig. 2 shows a deck plan. She has a length of 67·2 meters (220·5 ft.), breadth 8·2 meters (26·9 ft.), and is fitted with two sets of triple-expansion engines of about 4,600 indicated horse power. The boilers are four in number, and are of Schichau's locomotive type, designed to work at a pressure of 180 lb. per square inch, and no trouble whatever was experienced with them on the trial. The total weight of machinery, boilers with their water, etc., is 173 tons, or about 37·5 kilos. (82·66 lb.) per indicated horse power.—*Engineering.*

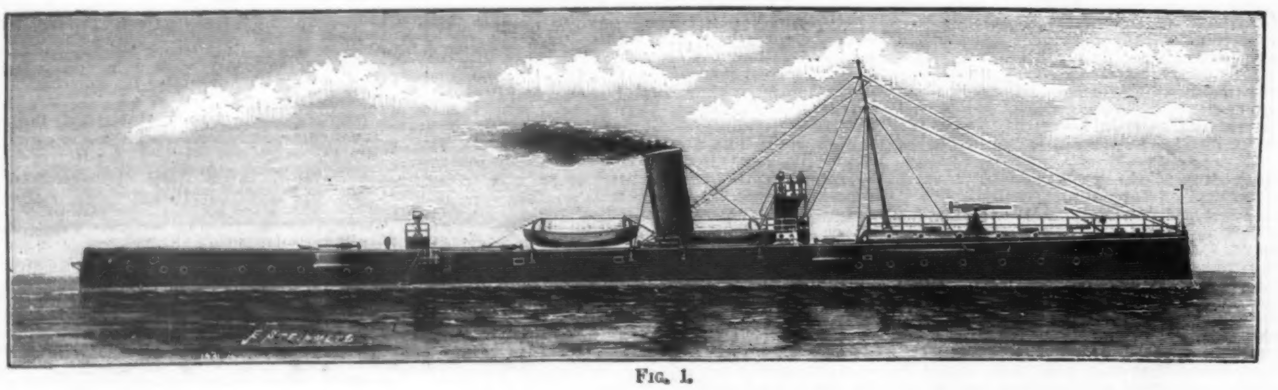
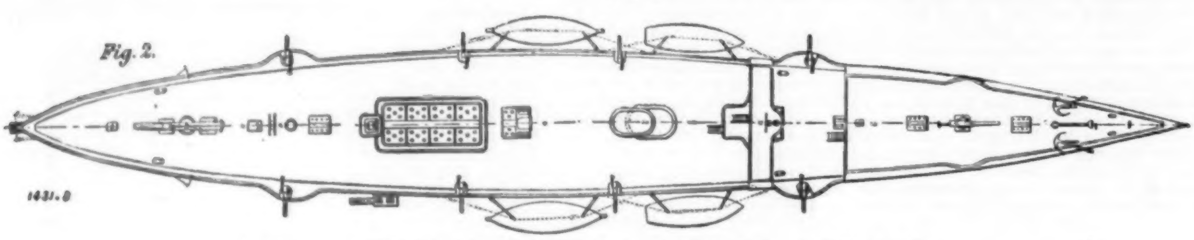


FIG. 1.

Fig. 2.



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THE AUSTRIAN TORPEDO CRUISER SATELLIT.

## THE BEST ALL-AROUND MODERN SHIP.

IN the fleet of five-and-thirty war ships which moved through the Narrows into the Hudson, where the Enterprise, the caravels, and afterward the Dogali brought the total spectacular array to a round forty, exclusive of torpedo boats and tugs, not one vessel was without its interest and merit. But if the question is asked, Which was the best all-around ship? the claimants, of course, would be reduced to a very few.

Our fleet, for example, would withdraw not only its gunboats Bennington, Concord, Yorktown, Bancroft, and Vesuvius, but its fine Charleston and Atlanta, which are surpassed by others of our vessels in battery power and speed. Spain would stand on her Reina Regenta, withdrawing the Infanta Isabel and Nueva España; Brazil would have her armorclad Aquidaban, and withdraw her Tiradentes and Republica; Germany would take her fine Kaiserin Augusta, and not the little Seeadler; France, the Jean Bart, and not the wooden Arethuse and the Hussard; Russia, doubtless, her Dimitri Donskoi above her General Admiral, also an armored cruiser, and her unarmored Rynda.

The four leading elements in an all-around war ship are armor, armament, speed and radius of action. For a commerce destroyer the two latter are relatively the more important, and for a line-of-battle ship, the two former. The fastest cruiser in the review was Argentine's Nueve de Julio, with her maximum of 22¾ knots and a beautiful craft in every way; but she is unarmored, and far inferior to the bigger ships in battery power. The Van Speijk, so welcome here because she is from Holland, has the good battery of six 6·7-inch and eight 4·7-inch guns, but is slow and unarmored. The Jean Bart, though the typical ugly-looking customer of the fleet, and a valuable cruiser, is yet in speed, gun power, and protection much inferior to several others.

We may next turn to the monitor Miantonomoh and to the Aquidaban, the only strict battle ship. The former carries seven inches of compound armor on her sides and eleven and a half on her turrets; the latter, from seven to eleven inches on her water-line belt, and ten on the oval barbettes that protect the bases of the turrets. The armored deck and redoubt roofs are of steel, two to three inches thick. The Miantonomoh carries four 10-inch guns; the Aquidaban, four 9·2-inch and four 5·7-inch guns. The American monitor is a most valuable harbor defender, with her big guns in cylindrical turrets, and with her low freeboard offering a difficult mark. But as her speed is only 10½ knots, and there are several 20-knot vessels in the fleet carrying guns capable of piercing her seven inch side armor, it will be seen that she is not the best all-around vessel. The Aquidaban is far better in speed, having made nearly 16 knots, and an average of about 11 knots on the long voyage from England to Rio.

Turning to the cruisers, the first marked distinction between them is that some are armored and that others are protected only by their coal belts and by curved steel decks. Speed and battery power being equal, the armored cruiser would naturally be expected to be better than the unarmored. Our own cruisers are all unarmored. The Chicago, 4,500 tons, carries the most powerful armament among them, four 8-inch, eight 6-inch, and two 5-inch guns; but she has only 15½ knots speed, and is not quite as well protected as the later ships. The Baltimore, 4,600 tons, has nearly as heavy a battery, four 8-inch and six 6-inch guns, and 19½ knots speed. The Philadelphia, 4,324 tons, and the San Francisco and Newark, 4,083 tons each, carry batteries of twelve 6-inch guns each, and their speed is 19¾, 20⅙, and 19 knots respectively.

Leaving these for a moment and going to the British ships, we find the Blake, a vessel of 9,000 tons, nominally a protected cruiser, but having a steel deck six inches thick at the maximum, much surpassing in thickness the decks of our protected cruisers, and curving at the sides to 6½ feet below the water line. In fact she is practically an armored cruiser. She developed on her trial, under natural draught alone, 19¼ knots in a seven hours' run, and it is asserted that she would make from 21 to 22 knots with forced draught. She carries two 9·2-inch guns and ten 6-inch guns, and these latter are rapid fire. The casemates of her main-deck guns have six inches of steel to protect them, a great point of superiority. She can carry 1,500 tons of coal, or far more than any of our vessels, and can go 15,000 knots without recoaling. The Australia and Magicienne are 19-knot ships, and the former has a water line belt of armor and a main battery like the Blake's; but we need not dwell on them, since the British evidently put forward the Blake as their best all-around ship.

The Kaiserin Augusta is one of the finest and most satisfying cruisers in the line, and an honor to any navy. She is next in displacement to the Blake, 6,052 tons; the third in engine power, 12,600, being surpassed only by the Blake and the Nueve de Julio; has the excellent speed of 20·7 knots, and the powerful battery of twelve 6-inch and eight 4-inch guns. But on the whole the Blake surpasses her in the combination of aggressive and defensive power.

Of the Italian vessels the Dogali, though the smallest, is the fastest, 19⅝ knots. The other two, the Etna and the Giovanni Bausan, 17·5 knots, are remarkable for carrying each two 10-inch guns, besides six 6-inch. They are all, however, unarmored, and are outclassed by the Blake. The Spanish Reina Regenta, once the fastest and most powerful protected cruiser in the world, was one of the very foremost in all-around efficiency in the review. When we say that with 4,750 tons displacement she has 11,500 horse power, 20·6 knots speed, and carries four 9½ inch, and six 4·7 inch guns, a sufficient idea is given of her admirable qualities. The Russian armored cruisers Dimitri Donskoi and General Admiral are also valuable ships, with fine batteries, but are rather too slow. Of them, as of Brazil's powerful Aquidaban, it may be said that a little more displacement is needed to work out the best results in their respective classes.

The Blake, therefore, seems entitled to first honors for all-around efficiency, both in battle and for cruising as a commerce destroyer, taking into view speed, armor, battery power, and coal endurance, and giving fair relative value to each.

We may add that Admiral Hopkins, after inspecting the New York, frankly told Captain Philip that she was superior even to the Blake.—*New York Sun.*

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THE cocoanut tree is the most valuable of plants. Its wood furnishes beams, rafters and planks, its leaves umbrellas and clothing, its fruit food, oil, intoxicants and sugar, its shells domestic utensils, its fibers ropes, sails and matting.

[FROM LA NATURE.]

## THE MANUFACTURE OF BICYCLES.

THE manufacture of bicycles has, during a few years past, assumed an importance that is daily increasing. This vehicle, of essentially French invention, has given rise to a special industry which has rapidly developed with our neighbors, the English, and notably in the manufacturing cities of Coventry, Birmingham and Wolverhampton.

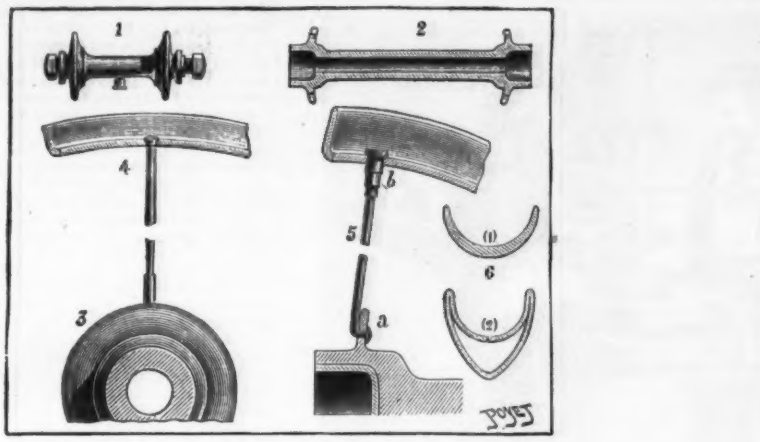
In France the manufacture remained for a long time stationary, because of that national spirit that causes us to hold in suspicion, as valueless, everything that is new. However, in presence of the ever-increasing number of cycles exported to us by our neighbors, it was necessary to submit to the evidence and recognize the fact that this object, formerly considered as a plaything, had entered into our customs and constituted an advantageously exploitable article of merchandise. An impulse was therefore given, and in three or four years factories sprung up almost everywhere. In the manufacturing centers there was only a transformation of fabrication, and where on the day before guns, hardware and other objects of iron and steel were produced, the following day cycles were constructing. At Lyons, Bordeaux, Nantes and Paris, on the contrary, there have been installed works thoroughly equipped for the manufacture of cycles to the exclusion of all other objects.

One of the most remarkable of those best equipped is that founded at Paris by Mr. Clement, and, in order to render our article more complete, we were anxious to visit this establishment, since we knew that we should find therein the most recent and most improved special machines.

It is not generally suspected what work is required by this vehicle, which has now been brought to wonderful lightness. Such lightness is obtained only through an irreproachable manufacture, and the light machines will always be high priced. But is it not remarkable that a man can, without fatigue, triple the speed with which he walks with this animated vehicle, which does not weigh, on an average, a quarter as much as he?

We are going, then, to describe the different phases to which must be submitted a cycle formed from bars and metal plates and passing through the hands of numerous workmen before becoming the elegant steel horse that we are acquainted with.

We shall pass in review the special machines employed in the manufacture, in measure as we shall have to point out the use of them. Meanwhile, we shall mention two very important groups—the multiple machine tools and the reproducing machines. The first of these comprise lathes, countersinks, boring machines and steam hammers—so many machine tools that permit the same workman to completely finish a piece in a single operation for the part that falls to him. The reproducing machines operate, so to speak, all alone, the workman being merely an auxiliary whose business it is to put the lathe or countersink in communication with the motive power, and to cut off such communication when the piece is finished. As their name indicates, these machines automatically reproduce, to the least details, a steel model or matrix placed opposite and fixed upon a frame. These wonderful machines do per day, on an average, the work of five or six men provided with simple tools.




FIGS. 1 TO 6.—PARTS OF BICYCLES.

1. Hub for straight spokes. 2. Hub for tangent spokes. 3, 4, and 5. Junction of the spokes. 6. Solid and hollow fellies.

The history of the manufacture of cycles will lead us to describe a machine that is equally very remarkable, and of which but a small number of specimens exist upon the Continent. We refer to a machine for brazing steel by electricity. It is of American make and has been imported thence into France. Let us mention, too, a machine analogous to that which is used in the state manufactories for making sheaths for the bayonets of the Lebel gun, and which is employed here for rendering cylindrical tubes of various forms conical.

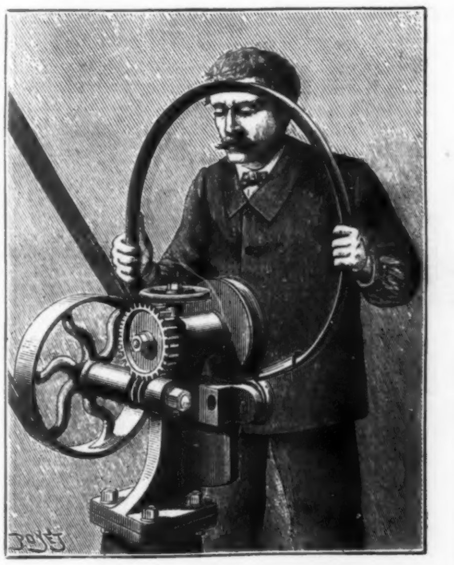


FIG. 7.—MACHINE FOR CURVING FELLIES.

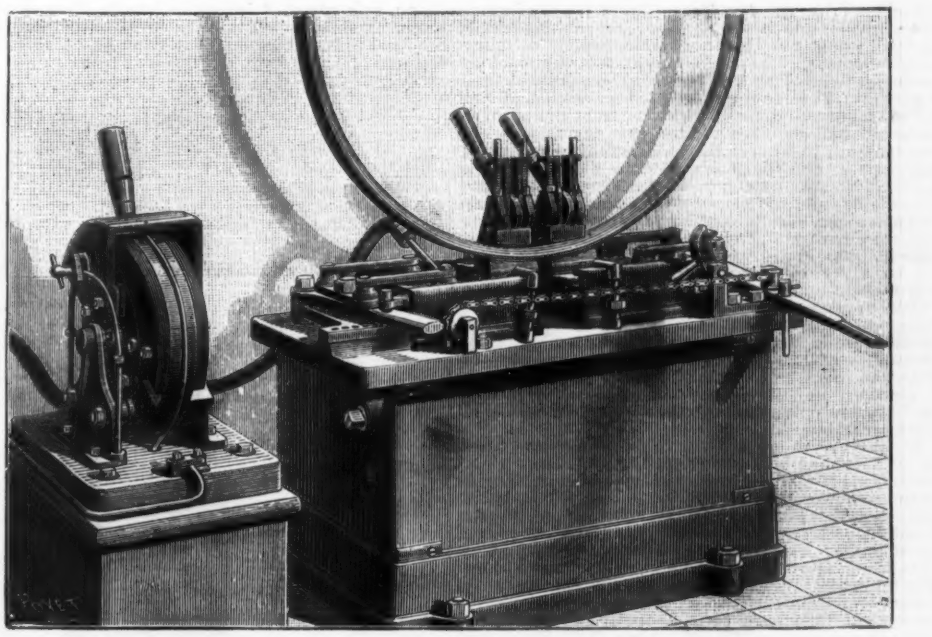


FIG. 8.—ELECTRIC BRAZING MACHINE.

In this study we shall occupy ourselves with the bicycle only, and we shall study the Clement model, which, however, affects a form generally known in England by the name of Humber frame. This model is manufactured as a cycle of the first rank by all solid houses.

In this bicycle we shall study in succession, (A) the wheels, (B) the organs of propulsion or transmission, (C) the steering parts, (D) the rolling parts, (E) the frame or body, (F) the pedals, seats and accessories, (G) the polishing, enameling and nickel plating, and (H) the mounting.

### A—THE WHEELS.

The wheels consist of four very distinct parts—(1) the hub, which has the external form shown in Fig. 1 for straight spokes, and of that shown in Fig. 2 for tangent spokes, which are so called because they are directed according to a tangent to the flange of the hub; (2) the spokes, which, as we have just said, are of two kinds; (3) the rim; and (4) the rubber tire.

(1.) *The Hubs.*—The hubs, of whatever kind they be, are shaped externally by means of the reproducing lathe, which delivers, finished, pieces of precisely the same dimensions. The hubs are of bronze, mild cast steel or of stamped steel. The holes designed to receive the spokes are bored in the following manner: The hub is mounted upon an axis terminating in a dividing plate that, without any measurement being taken, permits of boring any number of holes, regularly spaced. A rapid rotation and a longitudinal motion is given the drill dependent upon a hand lever. The axis of the dividing plate is mounted upon a pivot that permits of presenting the hub at the angle that it must make with the spokes. This work, then, is done almost automatically, and may, after a preliminary regulation of the angles, be intrusted to an apprentice or a woman.

(2.) *The Spokes.*—The spokes are of a very tenacious steel, capable of supporting a great tractive strain. For straight spokes there are very advantageously employed those called "upset," that is to say, of a greater diameter for the length of a centimeter on the threaded end that enters the hub. In this way is avoided the breakage close to the flange, owing to shearing and to weakening due to the threading. They are connected with the rim at the other extremity by a spreading head (Figs. 3 and 4). The heads are made by a special machine. The threading is executed with flat screw taps and is done by hand.

The tangent spokes, on the contrary, are connected with the hub by a head and with the rim by a bronze or steel nipple (Fig. 5, *a* and *b*). By reason of their arrangement, the tangent spokes, which are intercrossed and connected with each other, render the wheels very rigid and may be employed of smaller size with-

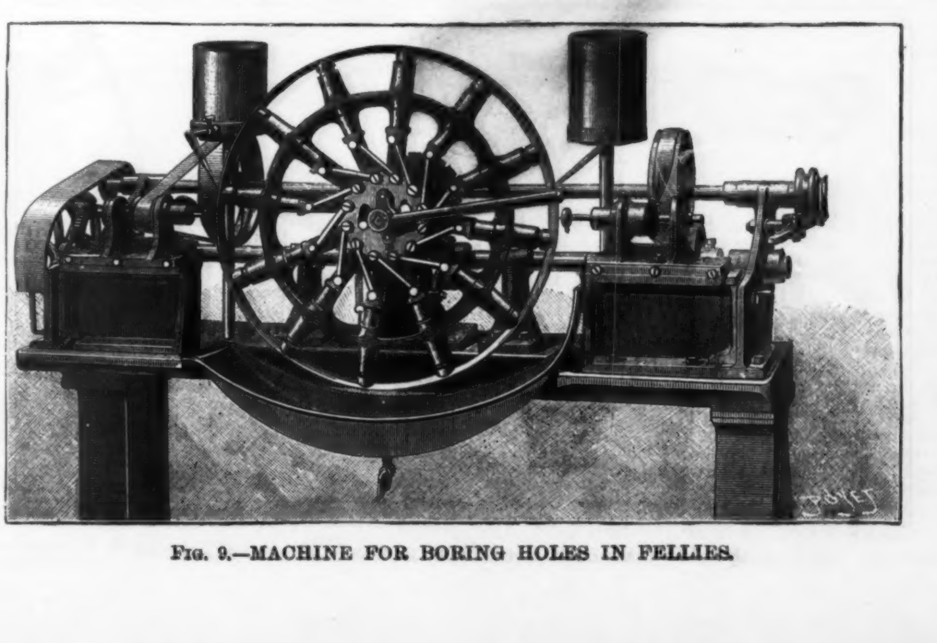


FIG. 9.—MACHINE FOR BORING HOLES IN FELLIES.

out fear of breakage. So, despite the difficulty of mounting, they are employed for very light wheels and carefully constructed machines.

(3.) *The Rims.*—The rims are of two kinds, solid and hollow (see sections in Fig. 6, Nos. 1 and 2). They are formed from a bar, rolled to the desired gauge,

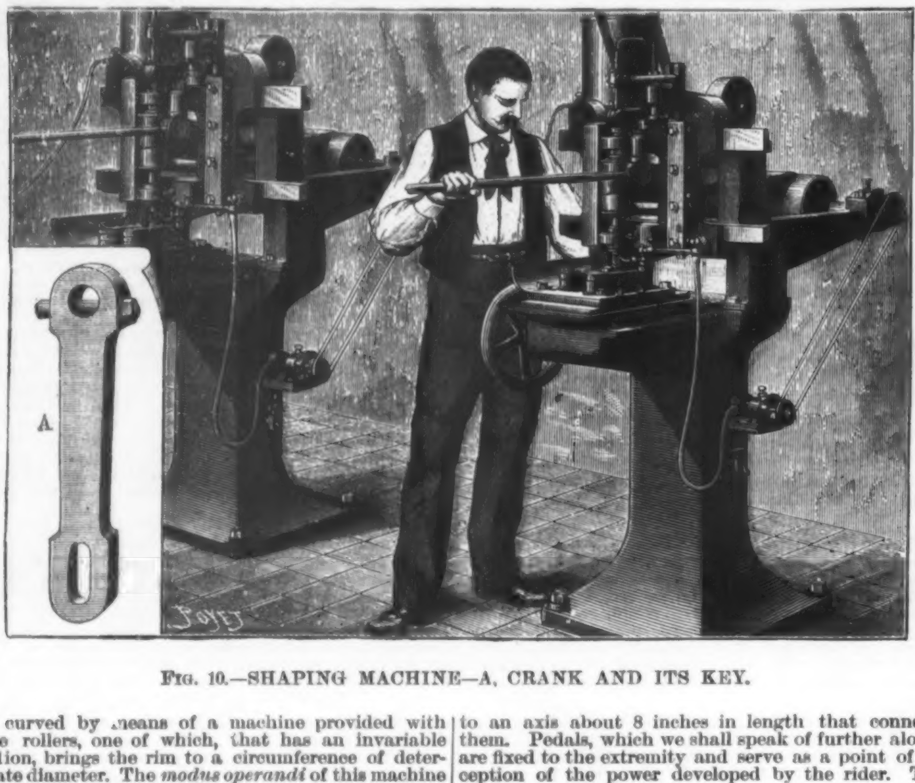



FIG. 10.—SHAPING MACHINE—A, CRANK AND ITS KEY.

and curved by means of a machine provided with three rollers, one of which, that has an invariable position, brings the rim to a circumference of determinate diameter. The *modus operandi* of this machine is represented in Fig. 7. The rollers are movable and must have, in hollow and relief, the section of the rim to be curved, without which it would certainly be flattened and distorted during the operation. The two ends, cut to a bevel, have hitherto been united by brazing. At the Clement works the electric welding machine, that we have spoken of above, is employed (Fig. 8). The felly is placed perpendicularly upon an insulator. An elastic coupler joins the two extremities, which are cut off square. By means of a commutator and a powerful exciter, a current is passed that quickly raises the steel to a soldering white, and the felly is then removed and placed under a small stamp, which equalizes it while hot. After cooling, there no longer exists any trace of the assemblage. This machine is sure in its operation and does its work quickly. The felly is afterward hammered upon a conical form, which rounds it perfectly, and is then straightened in its place upon a polished cast iron plate called a "marble." It now only remains to bore the holes for the reception of the spokes.

For this operation the establishment employs a special and very ingenious machine (Fig. 9). It is a wheel with strong jointed spokes that elongate or shorten to the same extent and simultaneously. It is, therefore, adapted for the reception of rims of all the usual diameters. The spokes, when they are put in place, form an angle with the plane of the rim. In view of this, the wheel is mounted upon a stationary frame. The boring apparatus, on the contrary, operates upon a distinct and movable frame that permits of placing the drill in the desired direction, corresponding to the angle of which we have just spoken. The division of the points to be bored is effected automatically by the dividing plate. After a polishing of the external surface and a furnace enameling in black or colors, the rim is finished and ready to be delivered to the workman who mounts the wheels. The latter receives at the same time the threaded hub and the threaded spokes of exact length. He first puts all the spokes in place, and then, after successive trials, succeeds, by screwing or unscrewing the spokes, in putting the rim in a perpendicular plane passing through the center of the hub, which is the mathematical position it should have.

B—THE PROPELLING AND TRANSMITTING PARTS.

The bicycle is actuated by means of two levers or cranks that point in an opposite direction with respect to an axis about 8 inches in length that connects them. Pedals, which we shall speak of further along, are fixed to the extremity and serve as a point of reception of the power developed by the rider. The axis of the cranks traverses the bottom of the frame between the two wheels, and at about one foot from the ground. The best length for the cranks, as learned from experience, is 6½ inches. Yet it is well to select a bicycle the extremity of the cranks of which is provided with a longitudinal aperture of 1¼ inch that permits of fixing the pedals at a distance of from 5½ to 7 inches from the axis. Every wheelman can thus, at his will, select the length that is best suited to his strength, to the country that he is to traverse, and to the speed that he wishes to adopt. Fig. 10 shows at A the conical key by means of which the crank is fixed to the axis. This arrangement permits of easily taking off the cranks if it becomes necessary. The head into which the key passes is shaped internally by means of the drill of the boring machine. The external contours are formed by means of a shaping machine (Fig. 10). The aperture for the adjustment of the pedal is formed with a milling machine. The slide is afterward finished with a proper reamer. The crank is mounted upon a plate that moves forward automatically at the rate of 0·004 of an inch per stroke of the punch.

The hind wheel is the motive one and propels the entire system. The rotary motion executed by the cranks is transmitted to it by means of two sprocket wheels connected by an endless chain, and fixed, one of them, upon the axis of the cranks on one side, and the other at one of the extremities of the hub. This arrangement, which it has not been possible to improve upon up to the present, is bad, in that all the work is effected upon one of the sides of the machine and the continuous stresses may, in the long run, twist the frame. The rear wheel is usually 28 inches in diameter, inclusive of the rubber tire, and would consequently develop $28 \times \pi = 7{\cdot}2$ feet, say 3·6 feet per thrust of the foot, were the transmission effected with sprocket wheels of equal diameter. This would be inadequate, since, in order to obtain a certain speed, it would require a very rapid motion of the legs, which would be fatiguing and quickly put the rider out of breath. This has been remedied by the use of sprocket wheels of unequal diameter, the larger being at the axis of the cranks. In this way there is obtained, on an average, two revolutions of the wheel to one revolution of the cranks. To this effect, it is necessary that the number of the teeth of the large wheel shall be double that of the small one, and if the motive wheel is 28 inches in diameter, we say that the bicycle is multiplied to 56 inches.

The calculation of this multiplication, M, is obtained by the formula

$$M = \frac{N}{N'} \times D$$

in which N and N′ represent respectively the number of the teeth of the large and small wheel and D the diameter of the driving wheel.

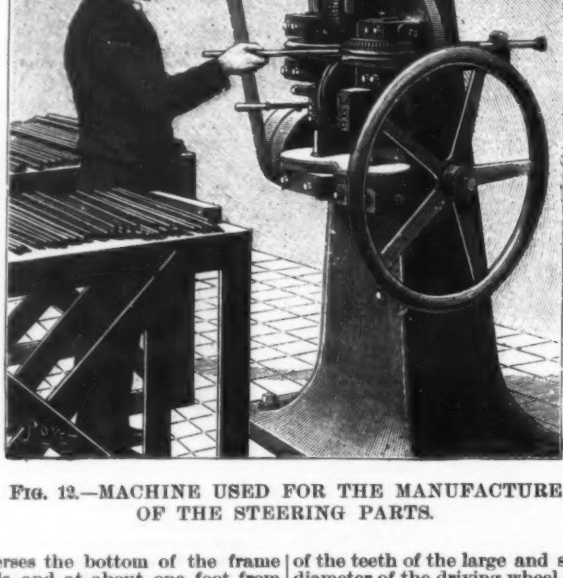


FIG. 12.—MACHINE USED FOR THE MANUFACTURE OF THE STEERING PARTS.

The sprocket wheels (Fig. 11, No. 1) are of stamped steel or cast steel.

The sprocket wheel is fixed upon the axis of the cranks by means of a flat key, and upon the hub by a thread so arranged that the traction of the chain tends to tighten it. It is sometimes, too, made in a piece with the hub, but such an arrangement presents many inconveniences, the chief of which is that when the sprocket wheel is worn out it is necessary to change the entire hub—one of the most important parts of the machine. The length of the links of the chain is calculated according to the form, size and spacing of the teeth. The side pieces, A, are punched out of steel plate, as are also the connecting parts, B. The riveting is done by a special machine run by steam. This chain once riveted presents a certain amount of rigidity. The Clement works have a very simple machine that serves to make them flexible. An axis actuated by steam carries six sprocket wheels, and another axis parallel with it, placed at the distance that separates the axis of the cranks from the hub, carries six other sprocket wheels. Chains cut to the proper length are placed thereon. A very rapid motion is given to the whole, and at the end of an hour the chains are replaced by others and are ready to be put in place on the bicycle.

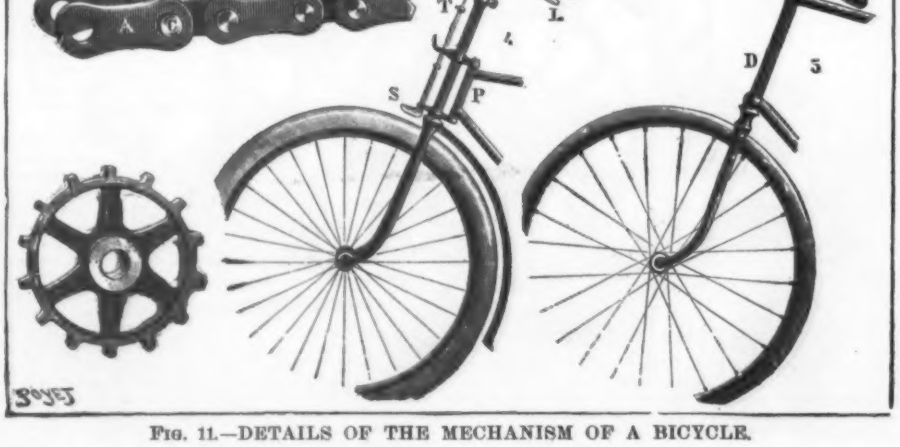



FIG. 11.—DETAILS OF THE MECHANISM OF A BICYCLE.

1. Sprocket wheel. 2. Pitch chain. 3 and 4. Steering mechanism.

C—STEERING PARTS.

The steering parts, which might also, with good reason, be called balancing parts, are represented in Fig. 11 (Nos. 3 and 4). They consist (1) of a wheel, (2) of steering bar and handles, and (3) of a fork. Of the wheel we shall say nothing except that it is identical with the driving wheel, save the sprocket wheel fixed

to one of the sides of the hub. This wheel is also made a little lighter and is provided with fewer spokes, since it supports only a slight part of the load. The handles are formed of a hollow bar whose extremities are curved toward the rear. This bar is rendered conical toward its two ends with the steam hammer, and it is curved in a cold state by filling the tube with a pulverulent substance that prevents distortion in bending. The extremities of the handles are covered with rubber or horn. This part of the apparatus performs the same office for the wheelman as a balance pole does for a tight-rope walker, while at the same time permitting him to steer the machine. These two motions of balancing and steering are absolutely conjugate, and, in practice, become instinctive to such a degree that the cyclist holds himself in equilibrium and steers without any more effort of the mind than he exerts in the act of walking. The handle bar is adjustable, that is to say, it can be lowered and raised and the handles be put exactly within reach of the hands, whatever be the stature of cyclist. Finally, the fork serves to unite the steering bar and the wheel. Its two branches are of elliptic or cylindrical form, but conical in either case. It is the machine for making bayonet sheaths (Fig. 12) that brings tubes in a cold state to these different forms.

Another part that belongs to the steering system, without directly forming a part of it, is the brake. This consists of a horizontal hand lever, L (Fig. 11, No. 4), that acts upon a vertical rod, T, terminating in a block, S, whose pressure upon the rubber tire retards the motion of the machine.

### D—ROLLING PARTS.

At present, what are called ball bearings are exclusively employed. These are the most delicate parts in a bicycle, and those in which the machine often fails. The ball bearing consists essentially (Fig. 13, No. 1) of a hollow cylinder, C, terminating in two concavities of elliptic profile. Another cylindrical piece, A, called the axis, traverses the cylinder from one end to the other. One of the extremities carries a cone, H, which abuts at the end of the threading against a boss. Another cone, H', likewise screwed upon the axis, is movable. The two cones are provided with a concave depression so calculated as to leave an empty space between their surface and that of the concavity of the cylinder, C. This space is filled on both sides with steel balls, which place themselves in the two planes, P and P', under the pressure of the movable cone, H'. This cone may be sufficiently tightened to leave no play in any direction, yet the revolution of A and C with respect to one another is extremely easy. The play due to the wear of the cones can be constantly suppressed by the tightening of H'. The points of contact between the surfaces of friction are reduced to a minimum. Finally, as the balls take a rotary motion contrary to that of the axis, it may be admitted theoretically that the friction is slight. In practice it is of no consequence.

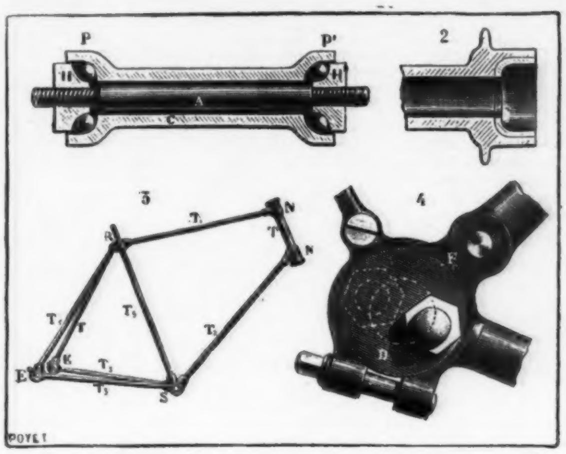


FIG. 13.—PARTS OF THE BICYCLE.
1. Ball friction. 2. Hub. 3. Frame. 4. Tension eccentric.

FIG. 15.—AN 1893 BICYCLE WITH PNEUMATIC RUBBER TIRE.

A wheel mounted upon a stationary frame and set in motion by hand revolves for twenty minutes, and its stoppage is hastened by the resistance of the air and by the defects in the homogeneousness of the mass. For the steering gear and the axis of the cranks it is indifferent whether the cone, H, be screwed to the right or to the left, but the movable cone, H', must be so screwed that the direction of rolling shall correspond to that in which it is unscrewed, without which the entire system would gripe.

As concerns the frictions, the hubs are fashioned on a lathe. As a general thing, one extremity is finished and then the other, and this requires two centerings. At the Clement works, there is a special lathe upon which one fixes the piece, which can be presented to the tools of the two ends without a new centering. We have already said that the hubs are of bronze or steel. In the latter case, the end concavities might be hollowed out directly, but the difficulties of tempering render preferable, in both cases, the use of tempered steel cups fixed by means of a hydraulic press. These cups are made by means of a special lathe.

The cones, as well as the balls, are shaped with the same tool. The balls after being turned are not exactly spherical. The finishing is done by a special tool consisting of disks revolving in opposite directions. These disks are provided with circular grooves equal in diameter to the balls. The latter are placed in these grooves along with emery powder and acquire a perfect sphericity therein. The last operation is the polishing, which is done in a cask filled with saw dust and having a rotary motion. The tempering slightly distorts the objects, and so the pieces that have been submitted to it no longer possess the mathematical profile indispensable for a perfect rolling. This defect is corrected by means of what are called American lathes. These machines, although of small size, are very strong and compact. They are employed with special tools that are capable of working hardened steel, the hardness of which is excessive and which cannot be attacked by the file.

For turning and threading the axles, the lathes employed are likewise exceedingly ingenious, and four of them can be run at once under the direction of one man. After the piece has been centered, the workman regulates the course of the tool and sets the lathe in operation. When the tool reaches the exact place where the threading must end, an ungearing takes place that stops its operation, pulls it back to disengage it and carries it to the starting point. The workman, being notified by a bell, has only to engage the tool anew.

FIG. 14.—PARTS AND ACCESSORIES OF THE BICYCLE.
1 and 2. Pedals. 3, 4, and 5. Saddles. 6, 7, and 8. Lanterns. 9. Monkey wrench. 10. Whistle. 11. Oil can. 12. Pedal elongator.

### E—THE FRAME OR BODY.

The frame or body consists of steel tubes, drawn out cold and without welding, assembled by means of coupling pieces of cast, stamped, or forged steel (Fig. 13, No. 3). The tube, T, carries two couplings, N and N, which constitute at the same time the receptacles for the balls of the steering rod. From the upper piece detaches itself a tube, $T_1$, assembled at R with a vertical tube, $T_2$, which serves as a sheath to the saddle rod. From there start two tubes, T and $T'_4$, which embrace the driving wheel and serve as a bearing point upon its axis for the rider's body. From N there starts a tube, $T_3$, which is coupled with the piece, S, which receives the axis of the cranks, and the lateral faces of which are hollowed out for the reception of the ball cups. Two tubes, $T_5$ and $T'_5$, detach themselves therefrom and rejoin $T_4$ and $T'_4$ through a coupling piece, E E', which carries the tension apparatus of the chain. This piece, E E' (Fig. 13, No. 4), consists of a collar with annular fastening. A disk, D, set into this, is capable of turning when the collar is loosened, and is fixed when the contrary is the case. This disk is provided with a cylindrical aperture in which are engaged the extremities of the axle of the driving wheel, which may be carried along by the revolution of the disk and thus traverse the horizontal distance that corresponds to a half length of a complete link of the chain. The chain elongates through wear, and it is the object of this eccentric to keep it always at the same tension. When the axle is at the extremity of its travel, a link is taken out and it is brought back to its first position, and so on. Let us say that it requires thousands of miles to make the elongation great enough to render such removal necessary.

To return to the frame: The tubes that compose this are first cut to the exact length by a special machine that makes a clean section without ragged edges. On another hand, the accessory pieces are bored out on a special lathe, which differs from the other lathes in that the face plate carries a movable jaw that grasps the piece and presents it to a centered fixed tool at the angle that the aperture must make with the other fixed directions of the mass.

The concavities designed to receive the ball cups are hollowed out at a single cut by means of a tool with a double cutting edge.

The coupling pieces and the tubes being thus prepared, the workmen proceed to the mounting, which is done on a rigid metallic form that has exactly the internal shape and dimensions of the frame. All things being in place, the separate parts are firmly joined and delivered to the brazer, who occupies a responsible position in the works resulting from the functions that he exercises. This brazing demands so much the more care in that there are constantly being employed thinner and thinner tubes that precautions must be taken not to burn and thus weaken. The brazing is done by means of a gas blowpipe, whose flame is directed upon the piece embedded in coke. After cooling, the brazed pieces are cleaned in a bath of slightly acidulated water, which removes the excess of borax. After being thoroughly washed in ordinary water, the frame is delivered to the filer, who removes the spelter and gives the junction pieces their definite form. The work of this man is of a delicate nature, for great care must be taken not to weaken the tube at the exact point where the coupling begins. The finishing of the frame consists in polishing it with an emery stick and brush and in enameling it.

### F—PEDALS, SADDLES AND ACCESSORIES.

The pedals (Fig. 14, Nos. 1 and 2) are generally made with bearings identical with those described above. The foot rests, now upon metallic plates cut out as shown in the figure, and now upon cylinders or pieces of square section made of rubber. The axle is turned and threaded like an ordinary axle, and the half-flat part that enters the slot of the crank is made on a shaping machine. The side plates are shaped in a reproducing machine. The cup for the balls is made on a reproducing lathe.

The saddles (Fig. 14, Nos. 3, 4 and 5) are manufactured by specialists. An endeavor is made to render them very elastic; hence combinations of springs that vary *ad infinitum* and that every house tries its best to present under a form more or less agreeable to the eye. Some that we have examined present exceedingly ingenious mechanical combinations. On account of the enormous production of cycles this industry has become largely developed.

The accessories comprise the oil can (Fig. 14, No. 11), the monkey wrench (Fig. 14, No. 9), the whistle (Fig. 14, No. 10) and the lantern (Fig. 14, Nos. 6, 7 and 8). These objects, varied to infinity in their form, are manufactured by special houses, some of which are very extensive, especially in England, for in France this branch of manufacture has not yet followed the ascending movement of the cycle properly so called.

### G—POLISHING, NICKEL PLATING AND ENAMELING.

Well equipped works, like those under considera-

tion, perform of themselves these three final operations. By reason of their special character they are performed in buildings distinct from those in which the mechanical work is done. The first polish is given with a coarse emery wheel, the second with a fine one and the third and final with a cylindrical tampico brush and emery putty.

The polished piece is next taken to the nickel plating department. Here it is cleaned, brushed with rotten stone, washed with water and then immersed in the galvanic bath for the length of time indicated by practice. The piece is afterward dried with sawdust and handed over to the polisher, who gives it a last polish with a piece of cloth smeared with a special paste.

If the piece is to be enameled, it is given into the hands of the enameler, who begins by stopping up all the apertures with cork and afterward immerses it entirely in a vat of enamel and then allows it to drain. After he has prepared a large enough number of pieces, he suspends them in a stove heated by gas to a temperature of about 160 degrees C., and leaves them therein for the length of time called for by experience.

During the course of execution all the pieces have received a number after rough mounting. When they are thus individually finished they are taken to the mounting shop, where special workmen "put the cycle on its legs," and afterward send it to the storehouse.

## THE UTILIZATION OF BLAST FURNACE SLAG.

By Herr R. ZSIGMONDY.

*Slag Bricks.*—The manufacture of slag bricks has attained considerable dimensions. The firm of Lurmann, Mayer & Wieking, of Osnabrück, has alone turned out about 5,073,400 since 1875. The manufacture has also been taken up by other ironworks, notably by the Schwechat Ironworks, near Vienna. The granulation of the slag, which is an essential part of the process, is effected by running the slag along a channel together with a stream of water into a reservoir, in which it is collected. The lime to be mixed with it, in the proportion of 1 part to 6 of granulated slag, is slaked with sufficient water to yield a moist sludge, and the two ingredients are thoroughly incorporated in a mill, in which the process is conducted in the following way: The mixed slag and lime are conveyed by a spout, to which a shaking movement is communicated, to a pair of rolls, which stop the access of unduly large fragments of slag or foreign bodies to the mixer proper, and mingle the slag and lime still more thoroughly while reducing them somewhat in size. The final mixing is effected by a set of three drums with radial projections fitting into each other with only a slight amount of clearance, so that the ingredients are brought into the most intimate contact.

A machine absorbing 2 to 3 horse power will serve to prepare the material for 9,000 to 10,000 bricks per shift of 10 hours. The mixture is moulded into bricks by a machine, which is provided with a hopper kept filled by the laborer in charge, and an arrangement whereby the quantity necessary to form one brick is let down into the mould and then the aperture closed, while the movable sides of the mould are brought into position by eccentrics, and by this means pressure is exerted upon the mass to shape and consolidate it. The finished brick is pushed out of the machine and the operations of filling the mould and applying pressure are repeated. A machine absorbing 7 to 8 horse power will turn out at least 9,000 to 10,000 bricks per shift, its capacity being limited chiefly by the time consumed in removing the finished bricks. The bricks thus prepared are weak at first, and have to be handled carefully, and must be stacked and protected from rain for the first day, a precaution that is not afterward necessary. They become sufficiently strong for use for building purposes after the lapse of six to twelve months.

Their hardening is partly due to the action of the granulated slag on the lime, and partly to the formation of calcium carbonate. Tests made at the Imperial Testing Station at Berlin show that these bricks have on an average a strength in compression of about 140 kilos. per square centimeter, and are little affected by saturation with water or by exposure to frost. The amount of water necessary to saturate them is about 12·4 per cent. On account of the hydraulic properties of a mixture of slag sand and lime, bricks can be immersed in water when only a week old without being disintegrated. From the nature of the case they are unsuited to withstand high temperatures, but they are not injured by a moderate degree of heat, *e. g.*, the temperature of furnace gases at 250° to 300° C. When used for ordinary structural purposes, such as building walls, they are cemented together by a mortar composed of slag sand and lime, and they have the useful property of affording a good hold for nails, which may be driven directly into them. No evolution of sulphureted hydrogen from them has been observed. They are also cheap, costing 9 to 10 florins per 1,000.

*Cast Slag Bricks.*—These are made by casting the slag in a mould built up of bars and angle pieces so arranged that layers of cubical spaces communicating with one another are formed, the whole being surrounded by sand, and the inlet placed at the bottom, so that the filling of the moulds takes place from below upward. Sufficient slag is poured to cover the whole set of bricks with a layer 10 centimeters thick, in order to insure slow cooling and the formation of the crystalline instead of the vitreous modification of slag, as the former is considerably the stronger. A minor use for slag is found in the production of a sort of moulding sand by mixing granulated slag sand with common sand, and its heat is utilized for drying sand moulds, whereby a saving of fuel is effected.

*Metallic Plaster.*—Under this name a mixture of slag with Portland cement has been in use for some time past in England and Belgium. The materials are first mixed dry, and then water containing a little sodium and ammonium carbonate to retard the setting is added, and the mixture compressed into paving tiles, *in situ*, the joints being filled in with shavings or other elastic material, to fill up crevices that may form when the fluctuations of temperature are considerable. Smaller tiles may be made, not necessarily *in situ*, and treated in a bath of sodium silicate before being laid.

*Slag Cement.*—Pinkenburg has given certain information on the preparation and use of slag cement in a communication to the Architectural Association of Berlin. There are about 10 slag cement factories in Germany, with an annual production of 600,000 tons. The Berlin market is supplied by slag cement made from the slag of the Blankenburg and Harzburg blast furnaces, and costing 5 marks per 170 kilos. delivered. The chief disadvantages of slag cement are its slowness in setting—15 to 22 hours—and its low specific gravity, which cause it to separate from the aggregate with which it is used. If exposed to frost during the time of setting, it is deteriorated, but is unaffected thereby when once it has set. It has given trouble in several cases when used under water, but appears well adapted for ordinary buildings exposed only to the air. When used as mortar the usual precautions, such as mixing to a stiff paste and thoroughly wetting the surfaces to be cemented, must be observed, and after the initial setting, the mortar should be kept as moist as possible to complete the process of hardening. As slag cement does not expand on setting, and from the nature of its constitution cannot blow, it may safely be used in cases where either tendency of Portland cement would be objectionable.—*Dingl. Polyt. J.*, 1892, 284, 233–237, *through Jour. Soc. Chem. Ind. of March* 31, 1893.

## CAMPHOR MANUFACTURING IN JAPAN.*

IN producing camphor, it is very important to choose a place which has a proper slope of ground and lying along a stream, and is also convenient for setting up the furnace and trough, and for transporting the raw material from which the camphor is to be extracted.

Having selected the proper place, the furnace to steam the chips of wood is first built, which should be of proper size to accommodate the iron pot to be used. The ground is next to be leveled and stones are laid down firmly and the whole built up with a mixture of gravel and pounded tenacious clay to a proper height; the whole is then covered with soft pounded clay both inside and outside. Before the clay is dried, the iron pot is set on and the external part of the pot is covered with the pounded clay adapted to the form of the furnace, and a small board called *kobuta* or little lid, and in shape like a fan (see Fig. A), is arranged on a level with the mouth of the pot. The door of the furnace Fig. B should be 1·7 feet in height and 8 inches in breadth, when the top of the pot is 2·85 feet in diameter, its bottom 1·3 feet in diameter and 1·1 feet in depth. The diameter of the furnace should be about 3 feet, upper part of its door should be covered thicker, so as to project forward a little, and its inner part should be widened a little to the right and left, giving more room for the fire space.

The furnace is now usually made with bricks and its external parts covered with pounded clay.

The bottomless tub, Fig. C, set over the iron pot for the purpose of steaming the chips of wood, is called koshiki and is made of *sugi* wood. Its inner surface only is planed and the staves have to be joined very closely, so as to prevent the escape of steam. Its height is 3·92 feet, and its upper orifice, called the *koppa-irekuchi* (or orifice for introducing chips), is 1·24 feet in diameter and lower one 3·02 feet in diameter. In the lower part of the *koshiki* or steam chest there is an orifice called *koppa-dashiguchi* (orifice for discharging chips), which is 10 inches long, 9 inches broad. A round sieve-like piece of board, Fig. E, 1 inch in thickness and 3·1 feet in diameter, having 30 or more holes either round or square, is made, called the *gesu-ita*, or *obuta*, or koppa-uke, the chip receiver. To set the *koshiki* or steam chest, 3 small round sticks are first laid across the iron pot, the *gesu-ita* is laid on the round sticks and then the *koshiki* or steam chest is set thereon. In the upper part of the *koshiki* a hole is made for introducing water, and in the bottom a bamboo tube, Fig. F, of about 6 inches in diameter is inserted, through which the water flowing down from the upper part of the *koshiki* or the surplus water from the iron pot finds its way out, thus regulating the amount of water, and is therefore called the water regulator.

If the *koshiki* is set on a pot, its external parts, together with the *koppa-dashiguchi* (orifice for discharging the chips), should be covered with pounded clay to the thickness of about 1·2 inches, and bound over with a rope and again covered with pounded clay. This is called *tsuchi-kakoi* (inclosing with clay). Sometimes it is inclosed with a cage made of bamboo to keep the clay from dropping off.

The water box, Fig. G, in which the vapor from the *koshiki* is condensed into camphor, is called the *fune* or trough. This fune or trough is made of the ¾-inch *sugi* (Cryptomeria japonica) boards. There are upper and lower fune or troughs, and joined together they make one whole. The lower one is 6 feet long, 3 feet broad, and 7½ inches deep. The upper one, Fig. G H, is 5·4 feet long, 2½ feet broad and about 1 foot high, and is without a bottom. It is separated in its middle part by a board; the upper half, being about 3 inches deep, is for holding the water, and the lower half is the place for receiving the camphor, where 8 or 9 pieces of thin board, Fig. 1, are fitted, each of which has a passage on one side for communication.

To set the *mizubune* or trough, first foundation in a level place is prepared 5-8 feet away from the *koshiki*. The lower trough in the ground is buried firmly, the trough is filled with water, two sleepers are laid upon its bottom, on which is set the upper trough, so that its bottom may be about 2 inches under water. The water is then conducted through a pipe, Fig. J, and falls into the upper trough, from which, when the latter is nearly full, it overflows through notch in the side down into the lower trough.

A bamboo tube, Fig. K, about 6 to 7 inches in circumference is laid between the upper part of the *koshiki* and the upper trough to communicate the steam of the *koshiki*, which is called the service pipe. The tube, Fig. R, of the upper trough, called the regulator tube, is made of a bamboo about 2½ inches in circumference, and it should be kept about 1 inch above the surface of the water.

The chips are chiefly obtained from roots of the camphor tree, or from the stem near the root, by chipping them off obliquely across the grain of the wood with a kind of adz, Fig. S. The chips should be thin and small, about 1½ to 2 inches broad and about ⅛ inch thick. If the chips are thin and small, and if their grain is oblique, the evaporation of the camphor is more rapid. The chips thus obtained are put into a basket and carried to the vicinity of the furnace. One basket contains about 115 lb. of the chips, and one person generally collects two basketfuls a day.

Before putting the chips in the koshiki, the water should be run into the iron pot by means of a pipe until it begins to overflow from the water regulator. The chips are then poured into the steam chest to about one-third of its capacity, and pressed down with a stick or pole from the top. More chips are then put in and pressed down: the same thing is done a third time, filling the chest quite full.

Before kindling the fire in the furnace, the orifices where the chips and the water were introduced, as well as the mouth of the water regulator, should be stopped with a mixture of mud and sawdust, or with some tenacious clay, to prevent the escape of the camphor. A strong fire should then be kindled and continued until the steam enters and fills the trough and begins to be emitted from the regulator tube of the upper trough, when the fire should be checked. The regulator tube is intended to furnish a means of testing the strength of the fire and should be plugged up with a stopper after being used.

After the fire has been checked as stated above, a sufficiency of fire wood should be put in the furnace to keep the fire up during the night without diminishing its strength and the furnace door should be closed with a stone. If the door is not properly closed, the fire would either burn too briskly and fresh ebullition take place, injuring the apparatus, or it might go out altogether. On the following morning the amount of water should be examined and the fire kindled as before, emptying the contents and replacing them with fresh chips. The process of boiling should be continued for 24 hours, the used chips being raked out from the proper outlet with a kind of shovel, called a sempa, which is about 2½ inches broad and is provided with a handle about 4 feet in length, and after being dried on a shelf in the upper part of the furnace are used for fuel.

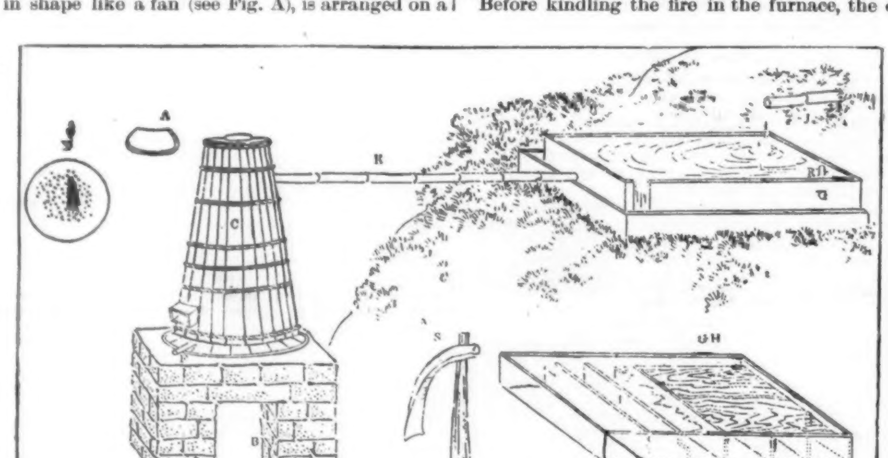
After this has proceeded for 10 to 15 days the upper trough is taken out and the camphor swept off. The one sweeping or scraping is called *hitohae*.

When the upper trough is to be taken the fire must be extinguished in the morning so as to allow the pot and trough to cool and the camphor to solidify sufficiently. The water in the tank is then drawn off and the upper trough gently removed. It is not necessary to remove the upper trough entirely, but simply to support it obliquely from one side with a stick while the camphor which adheres to the partition boards is scraped into a wooden tub; that which is floating on the water of the lower trough is skimmed off and is put into a pail 1½ feet wide at the top and 2·2 feet wide at the bottom and about 1½ feet deep.

After their having been used, the upper and lower troughs should be drained for future use.

The amount of camphor thus obtained at one firing or in over 10 days is generally 32 to 40 pounds, although the amount differs according to the skill of the workmen and the quality of the raw material used.

If a tub containing the camphor thus obtained is inverted with the lid on obliquely on a strong shelf




NATIVE JAPANESE CAMPHOR STILL.

* From the Tokio Sei-I-Kwai Medical Journal.

made for the purpose, the oil will begin to ooze out, and it should be received in another tub placed below.

After the oil has ceased to drip and the camphor has perfectly crystallized, the camphor should be put into a barrel or tub about 1·7 feet wide at the top and 1·5 feet wide at the bottom and about 1·9 feet high. The camphor put into the barrel should be made solid by pounding with a wooden mallet or pounder, and a double lid should be used to prevent the evaporation of the camphor. One barrel contains about 160 pounds. If to be exported, the lid should be pasted down with paper.

## THE SENSITIVENESS OF THE EYE TO LIGHT AND COLOR.*

By Capt. W. DE W. ABNEY.

THERE may be some here who have had the pleasure—or the pain—of rising very much betimes in a Swiss center of mountaineering in order to gain some mountain peak before the sun has had power enough to render the intervening snow-fields soft, or perhaps dangerous. Those who have will recollect what were the sensations they experienced as they sallied out of the comfortable hotel, after endeavoring to swallow down breakfast at 2 A. M., into the darkness outside. Perhaps the night may have been moonless, or the sky slightly overcast, and the sole light which greeted them have been the nervous glimmer of the guides' lanterns. By this feeble light they may have picked their way over the stony path, and between the frequent stumbles over some half hidden piece of rock lying in the short grass they may have had time to look around and above them, and notice that the darkness of the night was alone broken by stars which gave a twinkle through a gap in the clouds, or if the sky were cloudless, every star would be seen to lie on a very slightly illuminated sky of transparent blackness. Although giant mountains may have been immediately in front of them, their outlines would be almost if not quite invisible. As time went on the sky would become a little brighter, and what is termed the *petit jour* would be known to be approaching. The outlines of the mountains beyond would become fairly visible, the tufts of grass and the flowers along the path would still be indistinguishable, and most things would be of a cold gray, absolutely without color. The guide's red woolen scarf which he bound round his neck and mouth would be black as coal. But a little more light, and then some flowers among the grass would appear as a brighter gray, though the grass itself would still appear dark; but that red scarf would still be as black as a funeral garment. The mountains would have no color. The sky would look leaden, and were it not for the stars above it might be a matter of guesswork whether it were not covered over with cloud.

More light still, and the sky would begin to blush in the part where the sun was going to rise, and the rest would appear as a blue gray; the blue flowers will now be blue, and the white ones white; the violet or lavender colored ones will still appear of no particular color, and the grass will look a green gray, while the guide's neckgear will appear a dull brown.

The sun will be near rising, the white peaks beyond will appear tipped with rose; every color will now be distinguished, though they would still be dull; and, finally, the daylight will come of its usual character, and the cold gray will give place to warmth of hue.

But there may be others who have never experienced this early rising, and prefer the comfort of an ordinary English tramp to that just described; but even then they may have felt something of the kind. In the soft autumn evening, when the sun has set, they may have wandered into the garden and noticed that flowers which in the daytime appear of gorgeous colorings—perhaps a mixture of red and blue—in the gloaming will be very different in aspect. The red flowers will appear dull and black; a red geranium, for instance, in very dull light, being a sable black, while the blue flowers will appear whitish gray, and the brightest pale yellow flowers of the same tint; the grass will be gray, and the green of the trees the same nondescript color. A similar kind of coloring will also be visible in moonlight when daylight has entirely disappeared, though the sky will have a transparent dark blue look about it, approaching to green. These sensations, or rather

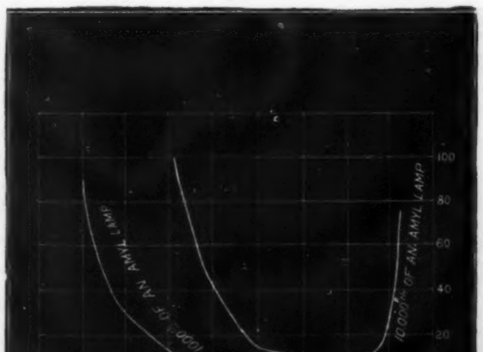



FIG. 1.—EXTINCTION OF SPECTRUM COLORS.

lack of sensations, of light and color, which as a rule attract very little attention, as they are common ones, are the subjects of my discourse to-night.

Experiments which can be shown to a large audience on this subject are naturally rather few in number, but I will try and show you one or two.

* A lecture delivered at the Royal Institution of Great Britain by Captain W. De W. Abney, C.B., R.E., D.C.L., F.R.S.

We are often told that the different stages of heat to which a body can be raised are black, red, yellow and white heat, but I wish to show you that there is an intermediate stage between black and red heat, viz., a gray heat. An incandescent lamp surrounded by a tissue paper shade has a current flowing through it, and in this absolutely dark room nothing is seen, for it is black hot. An increase of the current, however, shows the shade of a dim gray, while a further increase shows it as illuminated by a red, and then a yellow light. A bunch of flowers placed in the beam of the electric light shows every color in perfection; the light is gradually dimmed down, and the reds disappear, while the blue colors remain and the green leaves become dark. These two experiments show that there

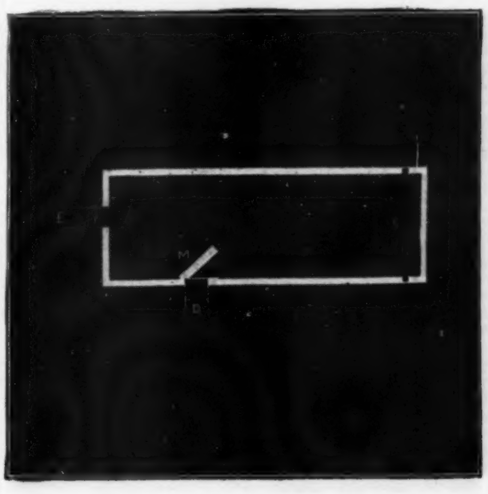


FIG. 2.—EXTINCTION BOX.

is a color, if gray may be called a color, with which we have to reckon.

Now the question arises whether we can by any means ascertain at what stage a color becomes of this gray hue, and at what stage of illumination the impression of mere light also disappears, and whether in any case the two disappear simultaneously.

As all colors in nature are mixed colors, it is at the outset useless to experiment with them in order to arrive at any definite conclusion, hence we are forced—and the forcing in this direction to the experimentalist is a very agreeable process—we are forced to come to the spectrum for information.

The apparatus on this table is one which I have before described in this theater, and it is needless for me to describe it again. I can only say that it has in all color investigations been of such service that any attempt on my part to do without it would have been most disadvantageous. The apparatus enables a patch of what is practically pure monochromatic light of any spectrum color to be placed upon the screen at once, and an equally large patch of white light alongside it, by means of the beam reflected from the first surface of the first prism.

It should be pointed out that this beam of white light reflected from the first prism of the apparatus, having first passed through the collimator, must of necessity diminish with the intensity of the spectrum, when the collimator slit is closed.

Having got these patches, the next step is to so enfeeble the light that their color and then their visible illumination disappear.

An experiment which well demonstrates loss of color is made by throwing a feeble white light on one part of the screen, and then in succession patches of red, green, and violet alongside it. The luminosity of the colored light gradually diminishes till all the color disappears, the white patch being a comparison for the loss of color.

If red, green and violet patches be placed alongside each other, and they are bedimmed in brightness together, it will be noticed that the red disappears first, then the green, and then the violet; or I may take a red and green patch overlapping, which when mixed form orange, and extinguish the color: the slit allowing red light to fall on the screen may be absolutely closed, and no alteration in the appearance of the patch is found to occur. This shows, I think, that when all color is gone from a once brilliant color, a sort of steel gray remains behind, and that red fails to show any luminosity when the green still retains its color.

The measurement of the extinction of color from the different parts of the spectrum was made on these principles. A box, similar to Fig. 2, was prepared, but having two apertures, one at each side. Through one the colored ray was reflected and through the other a white beam of light to a white screen. Both beams were diminished, and when the white and colored patches appeared the same hue, the amount of illumination was calculated. Fig. 1 shows graphically the reduction of illumination, when the D light of the spectrum is the same intensity as one amyl-acetate lamp at one foot from the screen. To measure the extinction of light, a box was made as in the diagram, closed at each end, but having two apertures as shown, Fig. 2. E is a tube through which the eye looks at S, which is a black screen with a white spot upon it, and which can be illuminated by light coming through the diaphragm, D, first falling on a ground glass which closes the aperture, and reflected on to it by M, a mirror.

The patch of light of any color being thrown on D, rotating sectors, the apertures of which could be opened and closed at pleasure, were placed in the path of the beam, thus enabling the intensity of the patch to be diminished. D could be made of any desired aperture, and thus the illumination of the ground glass would be diminished at pleasure. After keeping the eye in darkness for some time, the eye was placed at E, when the white spot illuminated by the color thrown on D was visible, and the sectors closed till the last scintilla of light was extinguished. This was repeated for rays at different parts of the spectrum, and the results are shown in Fig. 3 by the continuous curved lines. The diagram would have been too large had the same scale been adopted throughout for the ordinates; each curve is therefore made on a scale ten times that of its neighbor, counting from the center.

In the diagram the sodium light of the spectrum before extinction was made of the luminosity of the amyl-acetate lamp (hereafter called A L), which is about 0·8 of a standard candle, at 1 foot distance from the source. Before it ceased to cause an impression on the eye, the illumination had to be reduced to

$$\frac{350}{10,000,000}\text{ A L.}$$

$$\left.\begin{array}{l}
\text{E light to } \dfrac{65}{10,000,000} \\[2ex]
\text{F light ``} \dfrac{150}{10,000,000} \text{ or } \dfrac{15}{1,000,000} \\[2ex]
\text{G light ``} \dfrac{3,000}{10,000,000} \text{ or } \dfrac{3}{10,000} \\[2ex]
\text{C light ``} \dfrac{11,000}{10,000,000} \text{ or } \dfrac{11}{10,000} \\[2ex]
\text{B light ``} \dfrac{70,000}{10,000,000} \text{ or } \dfrac{7}{1,000}
\end{array}\right\}\text{Of its spectrum luminosity.}$$

There was one objection which might have been offered to this method, and that was to the use of the rotating sectors, and perhaps to the ground glass. This objection was met by first of all reducing the light by means of a double reflection of the beam forming the patch from one or two plain glass mirrors, and also by using a plain glass mirror in the box instead of a silvered glass. By this plan the light falling on the first plain glass mirror was reduced, before it reached the end of the box, 1,000 times; and again by narrowing the slit of the collimator, and also the slit placed in the spectrum, another similar reduction would be effected. All rays thus enfeebled were within the range of extinction. It was found that neither ground glass nor rotating sectors had any prejudicial effect, and therefore this extinction curve may be taken as correct.

In the curves there are two branches at the violet side, and this requires explanation. One shows the extinction when viewed by the most sensitive part of the eye, wherever that may be, and the other when the central portion of the eye was employed. The explanation of this difference in perception is chiefly as follows:

In the eye we have a defect—at least we are apt to call it a defect, though no doubt Providence has made it for a purpose—in that there is a yellow spot which occupies some 6° to 8° of the very center of the retina, and as it is on this central part that we receive any small image, it has a very important bearing on all color experiments. The yellow spot absorbs the blue green, blue, and violet rays, and exercises its strongest absorption toward the center, though probably absent in the very center, that is, in the "fovea centralis," and is less at the outer edges. That absorption of color by the yellow spot takes place can be shown you in this way. Any color in nature can be imitated by mixing a red, a green, and violet together, and with these I will make a match with white and then with brown, two very representative colors, if we may call them colors. Now if I, standing at this lecture table, match a white by mixing these three colors together, using a large patch, the image will fall on a part of the retina of considerably large area than the yellow spot, and it will appear too green for those at a distance; but it is correct for myself. If I place a mirror at a distance, and make a match again by the reflected image, the match is complete for us all, as we all see it through the yellow absorbing medium. If I look at it direct from where I stand, the match is much too pink. It may be asked why the comparison patches

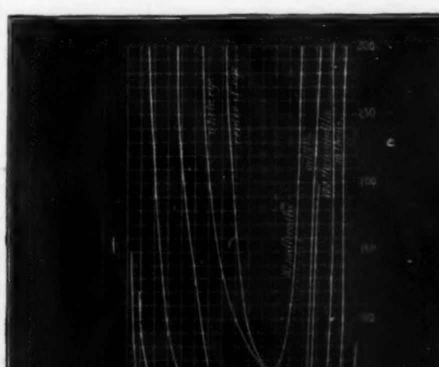


FIG. 3.—EXTINCTION OF THE SPECTRUM.

and the mixed colors do not always match, since both images are received on the same part of the retina. The reason is that the green I have selected for mixture is in the part of the spectrum where great absorption takes place, while the comparison white contains the green of the whole spectrum, some parts of which are less absorbed than others. I may remark that just outside the yellow spot the eye is less sensitive to

the red than is the center, and this is one additional cause of the difference. (See Fig. 5.)

More on this subject I have not time to say on this occasion, but it will be seen that the extinction of light for the center and the outside of the eye differs on account of this.

I must take you to a theory of color vision which, though it may not be explanatory of everything, at all events explains most phenomena—that is, the Young-Helmholtz theory. The idea embodied in it is that we have three *sensations* stimulated in the eye, and that these three sensations give an impression of a red, a green and a violet. These three *colors* I have said can be mixed to match any other color, or in other words, the three sensations are excited in different degrees, in order to produce the sensation of the intermediate spectrum colors, and those of nature as well.

The diagram, Fig. 4, shows the three sensations as derived from color equations made by Koenig. It will be seen that there are three complete color sensations, all of which are present in the normal eye. I would ask you to note that at each end of the spectrum only one sensation is present, viz., at the red end of the spectrum, the red sensation, and at the violet end the violet.

This is a matter of some importance, as we shall now see.

It will be recollected that in making the extinctions, the D light of the spectrum was made equal to one amyl-acetate lamp, and the other rays had the relative luminosity to it which they had in the spectrum before they were extinguished. The luminosity curve of the spectrum is shown in Fig. 5.

Suppose we make all the luminosities of the different rays equal to one, A L, we should not get the same extinction value, as shown in the continuous lines in Fig. 3. The violet would have to be much more reduced, but by multiplying the extinction by the luminosity we should get the curve of reduction for equal luminosities, and we get the dotted curves in Fig. 3.

It will be seen that it is the violet under such circumstances that would be the last to be extinguished, and that all the rays at the violet end of the spectrum would be extinguished simultaneously, as would also those at the extreme red. This looks a confirmation of the Young-Helmholtz theory which I have briefly explained, for we cannot imagine that it can be anything but a single sensation which fails to be excited.

The violet is extinguished when it is $\frac{15}{10,000,000}$ A L, that is, a screen placed 817 feet away and illuminated by an A L violet lamp would be invisible. The blue-green (F) light when it is $\frac{17}{10 \text{ millionths}}$ or 770 feet away. The green (E) light $\frac{35}{10 \text{ millionths}}$ or 550 feet away. The orange (D) light is extinguished as before at $\frac{350}{10 \text{ millionths}}$ or 180 feet away, while the red (C) light has only to be reduced to $\frac{2,220}{10 \text{ millionths}}$ or an A L lamp radiating C light would have to be placed only 67 feet away, while the radiation for an A L of the color of the B light of the spectrum would have to be diminished to but $\frac{2,600}{10 \text{ millionths}}$ or the screen would have to be placed 60 feet away.

It is therefore apparent that with equal luminosities the violet requires about 175 times more reduction to extinguish it than does the red, and probably about 25 times more than the green.

This being so, I think it will be pretty apparent that, at all events from the extreme violet to the Fraunhofer line, D, of the spectrum, the extinction is really the extinction of the violet sensation, a varying amount of which is excited by the different colors. If then we take the reciprocals of the numbers which give extinction of the spectrum, we ought to get the curve of the violet sensation on the Young-Helmholtz theory. For if one violet sensation has to be reduced to a certain degree before it is unperceived, and another has to be reduced to half that amount, it is evident that the violet sensation must be double in one case to what it is in the other; that is, the degrees of stimulation are expressed by the reciprocal of the reduction.

Such a curve is shown in Fig. 5 (in which also are drawn the curves of luminosity of the spectrum when viewed with the center of the retina and outside the yellow spot). And it will be noticed that it is a mountain which reaches its maximum about E. Remember that the height of the curve signifies the amount of stimulation given to the violet sensatory apparatus by the particular ray indicated in the scale beneath.

Turning once more to Fig. 3, it will be noticed that if any one or two of the three sensations are absent, the persons so affected are what is called color blind. Thus if the red sensation is absent, they are red-blind; if the green, then green-blind; if the violet, then violet-blind. If both red and green sensations are absent, then the person would see every color, including white, as violet. The results of the measurement of the luminosity of the spectrum by persons who have this last kind of monochromatic vision should be that they give a curve exactly or at all events very approximately of the same form as the curve given by the reciprocals of the extinction curve obtained by the normal eye, as the violet sensation is that which is last stimulated.

It has been my good fortune to examine two such persons, and I find that this reasoning is correct, the two coinciding when the curves for the center of the retina are employed.

Further, I examined a case of violet blindness, and measured the luminosity of the spectrum as apparent to him. Now if the Young-Helmholtz theory be correct, then in his case the violet sensation ought to be absent, and the difference between his luminosity and that of the normal eye ought to give the same curve as that of the violet sensation. This was found to be the case.

Again, the reciprocal of the extinction curves of the red-blind and green-blind ought to be the same as those of the normal eye, for the violet sensation must be present with them also. This was found to be so. We have still one more proof that the last sensation to disappear is the violet.

If we reduce the intensity of the spectrum till the green and red disappear to a normal eye, and measure the luminosity of the spectrum in this condition, we shall find that it also coincides with the persistency curve. On the screen we have a brilliant spectrum, but by closing the slit admitting the light and placing the rotating sectors in the spectrum and nearly closing the apertures, we can reduce it in intensity to any degree we like. The whole spectrum is now of one color and indistinguishable in hue from a faint white patch thrown above it. If the luminosity of this colorless spectrum be measured, we shall get the result stated. The curve obtained in this way is in reality identical with the other curves. By these four methods then we arrive at the conclusion that the last color to be extinguished is the sensation which when strong gives the sensation of violet, but which when feeble gives a blue gray sensation.

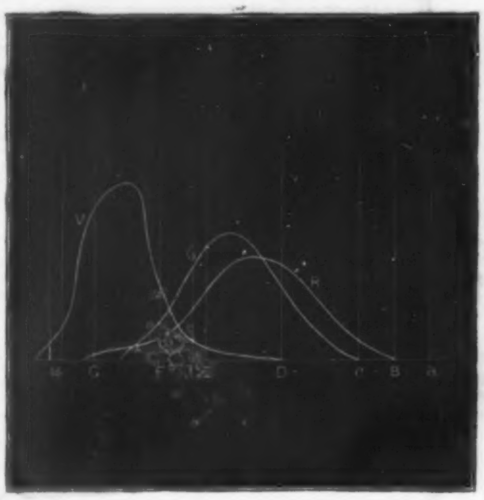


FIG. 4.—COLOR SENSATIONS.

One final experiment I may show you. It has been remarked that moonlight passing through painted glass windows is colorless on the gray stone floor of a cathedral or church.

We can imitate the painted glass and moonlight. Here is a diaper pattern of different colored glasses, and by means of the electric light lantern we throw its colored pattern on the screen. The strength of moonlight being known, we can reduce the intensity of the light of the lamp till it is of the same value. When this is done it will be seen that the pattern remains, but is now colorless, showing that the recorded observations are correct, and I think you are now in a position to account for the disappearance of the color.

I have now carried you through a series of experiments which are difficult to carry out perfectly before an audience, but at any rate I think you will have seen enough to show you that the first sensation of light is what answers to the violent sensation when it is strong enough to give the sensation of color. The other sensations seem to be engrafted on this one sensation, but in what manner it is somewhat difficult to imagine. Whether the primitive sensation of light was this and the others evolved, of course we cannot know. It appears probable that even in insect life this violet sensation is predominant, but at all events existent. Insects whose food is to be found in flowers seek it in the gloaming, when they are comparatively safe from attack. Prof. Huxley states that the greater number of wild flowers are certainly not red, but more or less of a blue color. This means that the insect eye has to distinguish these flowers at dusk from the surrounding leaves, which are then of a dismal gray; a blue flower would be visible to us while a red flower would be as black as night. That the insects single out these flowers seems to show that they participate in the same order of visual sensations. I venture to think, without adopting it in its entirety, that these results at all events give an additional probability as to the general correctness of the Young-Helmholtz theory of color vision. Where the seat of color sensation may be is not the point, it is only the question as to what the color sensations make us feel which the physicist has to deal with. The simpler the theory, the more likely is it to be the true one, and certainly the Young-Helmholtz theory has the advantage over others of simplicity.

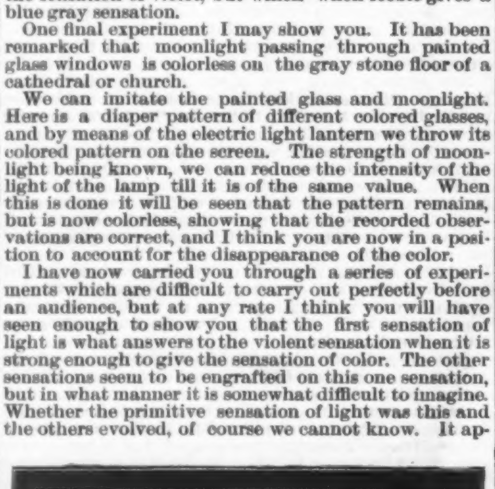



FIG. 5.

## THE ORIGIN OF THE SIGMOID FLEXURE AND THE APPENDICULA VERMIFORMIS OF THE HUMAN COLON.

THE sigmoid flexure of the human colon is the necessary result of the change from quadruped to biped, from the horizontal to the vertical position.

The colon having formerly occupied the position of an easy curve, its greatest weight rather tending from the anus downward toward the umbilicus, thus rather straightening that part of the colon which now contains the sigmoid flexure. The gradual change from the horizontal to the vertical position changed all this radically, formed of the colon an arch, whose columns bent and kinked from sheer force of the weight they were compelled to support.

The appendicula vermiformis, or worm-like appendage, resulted likewise from the same cause, namely, the upright position. Through means of the weight of the feces or excreta causing the extension of the colon beyond and below the ileo-cæcal valve, from the difficulty of expelling the accumulations in the same, it finally became constipated, peristaltic action becoming more and more difficult, expansion and contraction of the muscles ceased partly, and finally altogether, with it also a diminishing of the circulation of blood must have taken place. What other result could there be than that this part of the colon became useless and consequently doomed to gradual reduction and final disappearance?

Lady Lake, Fla. CHAS. F. SCHNEIDER.

## WATER CURES FROM CLINICAL AND EXPERIMENTAL POINTS OF VIEW.*

By Prof. WILHELM WINTERNITZ.

IT is now thirty years since I began to investigate the action of water in its various temperatures and aggregate forms, and to observe how the thermic and mechanical influences manifest themselves in the healthy and in the sick. The first results aroused in me a lively desire to do away with hydrotherapy as a specialty and to make it the common property of society in so far as it merited general adoption. But after hydrotherapy had received an apparent impetus during the sixties, and especially after the question of the regulation of warmth had come to stand in the zenith of physiological interest, my hopes began to sink, and to-day, in common with other distinguished clinicians, I must declare that the proselytizing power of my own convictions has not proved equal to the achievement of this ideal. Nevertheless, the dissemination of theoretical knowledge has been greatly promoted; hundreds of my direct and indirect pupils are to-day conducting hydropathic institutes, and hundreds of thousands receive treatment for their maladies in accordance with my principles.

A few years ago I believed that the principles of my method were firmly established, and I shall endeavor briefly to sketch its main features, and to show that it is possible to speak in a rational manner of thermic and mechanical effects upon the organs and their functions. I cannot, of course, go into details here, but will simply assert that we are thus enabled to elevate, depress or modify the supply of nerve force. I merely remind you that we are in position to recall to normal perception anæsthetic portions of the body, and of again producing anæsthesia through the application of cold. We are able to exert an action not alone on the peripheral nerves, but also through the latter, by reflex action, on the central organ, and even on the gray cortex of the brain.

I have not hesitated to learn from laymen. In Grufenberg, for example, I saw a young, robust patient suffering from severe circular insanity, characterized by great depression, with feelings of anxiety, notions of persecution, self-reproaches, abstinence, impurity, etc., which alternated with symptoms of most pronounced excitation. Patient had just experienced a violent attack of mania, during which four attendants placed him gently upon a couch prepared with moist padding (water bed). The first shock of the cold sheet resulted in giving the patient a few moments' rest, and the interval was utilized by the attendants in wrapping up the patient tightly, closing the moist ends over his head, and thus forming a kind of therapeutic strait jacket. After five minutes the patient began struggling to remove the sheet, whereupon he was placed on another couch similarly prepared, and the interval of rest produced reflexively proved of longer duration. Thus from morning until evening sixteen "wrappings" were performed, the attack of mania then vanishing completely. We physicians would perhaps have hesitated to subject to such a thermic process a subject suffering from accelerated circulation and violent congestions to the head. The result was an extraordinary surprise to me, and subsequently I succeeded by following this method in treating satisfactorily very severe circular forms, with the severest stages of excitation and koprolalia. This case proves that through the periphery we can exert reflex action upon the central organ in this manner. The nervous condition depends on the impulses which are conducted to the center from the periphery. When this stimulus gradually fades away, and the peripheral vessels, through repeated stimulation, are brought into a state, not of paretic, but rather of tonic enlargement (which, under the co-operation of the inhibitory nerves, may become active), the modified distribution of the blood will have a powerful influence. It goes without saying that, aside from the influence upon the nervous forces, that exerted upon the circulation must also be taken into account, and we hope that psychiatric specialists will make experiments in this very form of nervous excitement, on a greater scale than hitherto. It is an

* From the *Internat. Klin. Rundschau.*

established fact that all forms of excitation are influenced by this procedure, especially sleeplessness, which is benefited by application of cold packings.

Much more important is the action on respiration and circulation through thermic and mechanical stimuli. Throwing but a few drops of water into a person's face, deep inspiration results and simultaneously a modification in the rhythm of respiration. Experiments which I have made with the respiratory apparatus have taught me that we are able, through thermic influence applied to the surface of the body, to produce a very powerful action on the exchange of gases—not alone, indeed, on the volume of the expired and inspired air, but also on the absorption of oxygen and the formation of carbonic acid.

But the influence which we can exert upon the circulation by means of thermic and mechanical stimuli applied to the surface of the body is far more striking. We can act at pleasure, not only upon the heart, but upon the peripheral vessels as well. We know that by irritating the source of the vagus, the frequency of the heart's action is modified. I have been able to show, with the acid of sphygmographic and sphygmanometric observations, that cold as well as heat effects a very transient acceleration of the heart's action, which then recedes, and which we can again through definite processes accentuate further and cause to reach a point of considerable elevation. The most palpable exhibition of this is in exophthalmic goiter. I have seen such a case in which, partly from thermic and partly from mechanical stimuli, the pulse, accelerated to 200, was depressed to 40 beats, in a few minutes. This I observed for the first time in the Sander Institute at Stockholm, where a similar result was obtained by means of strokes applied to the back. There are indeed manifold variations of methods with which to obtain the same effects—even through simple reflex irritation. Thus, for example, the heart's action may be retarded and the single contractions made more vigorous, by flowing foot baths, rubber tubes applied to the neck and back and by application of cold compresses to the heart region. By the application of thermic irritation, applied to the peripheral vessels and vaso-motors, we can effect contraction, relaxation with loss of tonic tension or with maintenance of the tone. It makes a great difference whether the vessels enlarge with loss or preservation of tone, since it is a fact established by various physiologists that the loss of vital power is much greater when the elasticity of the tissues and the tension of the vessels are relaxed; circulation is more favorably influenced when the vessels enlarge while preserving their tone. This we experience in fever, in which, with loss of tone, passive stases often supervene.

I would further mention the active hyperæmia which may be artificially produced by thermic irritation. Our efforts are often crowned with great success when we succeed in inducing the flow of blood to certain parts of the body. Let us imagine an acute arthritis rheumatica and neuralgia; some thermic disaster occurs in the form of a moist, continued draught of air, provoking reflexively in the nerve disturbances of circulation, consisting of reflexive contractions of the vessels of the organ in question. In such a diseased organ the degenerative products—in the muscle they consist chiefly of acids—accumulate, through which, if less alkaline blood flows by, the nerves of sensibility are irritated. If now, through massage, electricity or thermic stimulus, a fluxion is produced, the vessels are caused to enlarge actively, more alkaline blood is introduced, and we succeed in overcoming the muscular rheumatism soon after its supervention, or in lessening the pain of chronic conditions. In the nerve a similar process is exhibited. A tetanized nerve yields an acid reaction on cross section; if we now succeed in bringing alkaline blood to the inflamed nerve, thus neutralizing the acid, the entire process can be terminated. This truth holds good in countless cases.

Far more important is the *passive hyperæmia* which is at the root of many processes, and which may be affected by thermic and mechanical agents. I cite an example. A woman once came to me, who for two years had been suffering from continuous metrorrhagia, and in whom the gynecologists could diagnose nothing more than a hyperæmia and swelling of the uterus, and a cyanotically colored *os uteri*, obtaining no results from all manner of injections. I regarded the hemorrhage as *passive*, since the clinical symptoms seemed to suggest this view. I recalled a patient whom I had seen at the clinic of the famous Traube, complaining of hæmoptoic symptoms. To our great astonishment, Traube advised him to make foot tours in the mountains and to take a great deal of general exercise. From the dark sputum and the very tense pulse, Traube assumed the existence of a passive hyperæmia, and when I met this man subsequently in a party of mountain tourists in the Tyrol, I was enabled to convince myself personally of the good results from this therapy. In the case before me I resorted to vigorous methods calculated to elevate general tone, strengthen the pulse and induce a flow of blood to the periphery. The patient was given shower baths and flowing foot baths; she underwent thermic and mechanical treatment applied to the abdominal and lumbar regions and producing shock, whereupon the bleeding ceased after a few weeks. Likewise, in similar cases of persistent nose-bleed due to passive hyperæmia, I could usually obtain benefit by stimulating the circulation.

A very important question, which permits us to include within the province of thermic and mechanical actions an entire series of nutritive disturbances, is the *influence upon secretion and excretion*. Resorting to thermic and mechanical methods, we can affect the discharge of water through the skin, the kidneys and the lungs. Weihrich demonstrated that a few minutes' friction applied to the surface of the skin augmented the excretion 60 per cent. In a whole series of chronic diseases, it is very important to remove the customary burden from certain afflicted organs. Numerous experiments have led me to conclude that it is possible, acting upon the surface of the skin thermically and mechanically, to produce more favorable conditions of circulation and more copious diuresis. The fact that we are able to augment the frequency of the heart's action and its vigor, as well as to overcome disturbances of circulation in many cases with almost physical certainty, has prompted me, as well as those of my colleagues who treat disease according to my methods, to obtain frequent relief even in organic troubles, especially in disturbances of cardiac compensation.

A few years ago I believed that the fundament of my system was permanent, and that we needed simply build farther. Then came suddenly—overturning and transforming everything—the new etiological discoveries and conclusions. How could I believe that my method was rational, unless I could show that I could act on all the various micro-organisms with water, and unless I could influence the etiological factor? The need of comprehending causal relations, which is common to all physicians and investigators, was sorely tried; the basis of our therapy was in a measure destroyed, and we were forced back upon purely empirical support. To be sure, we continued to cure the sick, but I was naturally unwilling to concede that my methods were irrational. But the bacteriological billows have been somewhat lulled, and further researches showed that there are ever in the morbid organism a number of forces and processes which are capable of resisting infection. And so I inquired, "Is it not possible that our therapy possesses a certain power to influence this natural resisting energy of the organism?" In this respect we have learned not a little. At the outset it is generally known that the healthy and vigorous organism can combat infection far better than the diseased, and we have shown that our therapeutic methods really enable us to invigorate the organism.

We were accordingly constrained to find a basis for a strengthening method. But people are always somewhat skeptical where there are no numbers and figures. Then appeared an interesting work by two Italian investigators, who showed that thermic and mechanical stimuli materially increase the resistance of the muscles to fatigue, and that thus may be explained the tonic effects of thermic and mechanical measures. It was thought to test the muscular energy by the dynamometer, but the latter permits of no precise determinations. Mosso then constructed an apparatus which enables us to measure the muscular vigor quite objectively. Mosso showed that every man exhibits a curve peculiar to himself and individual in form, the latter remaining the same after the lapse of years. Voluntary contractions of the fingers lift weights, so long as this is possible, and the liftings are recorded on paper. Now it has been shown that, under normal conditions, an individual is capable of lifting with the right hand 45 times 2 kilos., at intervals of 2 minutes; with the left hand, 50 times; following a cold bath at 10°, the working power is almost doubled. Warm baths reduce the number of the contractions; massage causes the fatigue to vanish. Warm baths, however, may also augment the resistance of the muscles to exhaustion, although in such case vigorous mechanical measures must be combined with the high temperature.

From the investigations of Brunner we know that micro-organisms are excreted in the perspiration; a quantity of intoxication products is likewise excreted through the urine. In various infectious diseases, the alkalinity of the blood diminishes; an alkaline urine becomes acid under the action of cold upon the organism. Hence, under the influence of cold more acids are excreted, imparting to the blood an augmented alkalinity. The investigations of others, again, have shown that the urotoxic coefficient of the urine in febrile diseases is elevated, under the action of cold, to five and six times the normal. A large quantity of toxic substances are disposed of through the urine, and the organism is liberated from the poisons.

It is a very interesting fact that in many forms of febrile disease the proportion of red corpuscles in the blood sinks materially (often by one half million and more), and that they reappear immediately after the crisis. They certainly could not have been formed within the few hours. We here have before us something which primarily produces the intoxication and the fever, namely, the loss of vascular tone. In individual vessels the blood corpuscles coagulate; these are excluded from circulation, and, according to Flueter, globular stases ensue. In such cases it is rational to proceed to an immediate restoration of the tone. I have shown repeatedly that it is an easy matter, after a cold bath and with the aid of the sphygmographic curve, to recognize the renewed tone of the vessels. Is it not possible that restoration of the tone before the crisis would tend to produce better and more favorable conditions of circulation? Clinical observations prove that, under treatment with cold, stasis is more infrequent than ordinarily.

And if I add to the foregoing my latest observation (as I have learned subsequently, the same thing was reported previously by Rovigi), that through the action of cold an artificial leucocytosis is effected, which, it is assumed, bears a relation to the destruction of the micro-organisms, it must be stated that we have a good foundation for the view that at last our methods are to be brought into rational accord with our present knowledge. The prosecution of further researches in this direction I warmly recommend to my professional colleagues.

## UNNECESSARY PAIN IN DENTAL OPERATIONS.*

By JAMES A. REILLY, D.M.D.

IT is not my intention this evening to attack any established theories or to attempt to overthrow any cherished opinions or prejudices. I simply desire to call your attention to a few points in everyday practice, and would prefer to suggest a few things you ought not to do rather than those you should do. Indeed, I am to address you from the standpoint of a patient in the chair rather than as the operator at its side.

One forenoon during my senior year at the Harvard Dental School, and while in charge of the dental department of the Bennet Street Dispensary, among the numerous patients was a lad of twelve or thirteen years. He went through the usual preliminaries required in order to have an inferior bicuspid tooth extracted. The operator mechanically picked up his mirror and pliers to examine the tooth, or what remained of it, and almost simultaneously with their introduction into the boy's mouth there was a terrific scream and a plunge that almost carried him through the window. An attempt at extraction by a street dentist had resulted in the removal of the crown, leaving the entire coronal portion of the pulp standing unprotected. The dentist simply plunged his pliers into the mass of living tissue. Was not that an abuse utterly reprehensible on his part? I think it was, and so would you, I believe, had you been the sufferer. Yet we are doing just such things every day in one form or another.

That "familiarity breeds contempt" is nowhere more noticeable than in the use of dental instruments and appliances. Not long since, a gentleman somewhat prominent in dental organizations told me he had not a dozen excavators in his possession; that he excavated all his cavities with the aid of the dental engine, and wished to wager me that I could not find a cavity in a tooth that he could not reach and prepare as well, if not better, with the engine than it could be accomplished with hand excavators. Upon being questioned if his patients did not complain of being hurt, he replied, "Confound the patients! my duty is to protect myself." If this gentleman could but be patient and operator at the same time, I have no doubt that he would be easily induced to trade some of his burs for hand excavators. Has he not, to say the least, become too "familiar" with his engine? This I consider an extreme case of abuse, for, allowing for a moment that all cavities may be reached (which I do not believe, unless he destroys a vast quantity of sound tooth substance), the time that is gained by its use is but a trifling compensation for the torture that is thus inflicted on children and excessively nervous adults, and I suppose he has such patients. He may run his engine slowly, use the sharpest burs and all the obtundents at his command, but does he diminish the loss of tooth structure thereby, or reduce the inherent antipathy to dental operations which the average patient has? Does he not absolutely destroy the last vestige of confidence the little one may possess who has been beguiled into the chair by its parent with unqualified assurance that "it will not hurt a bit"?

Another appurtenance, no less barbarous in some of the details than the untimely use of the dental engine, is the rubber dam. A prominent writer says, if it is at all difficult to apply, the rubber dam should not be used in the cases of the very young, very sensitive, or very nervous patients. How many of us draw the line at these classes? It is not my intention to point out the occasions for its use or to urge upon you its abandonment, for I consider it a *sine qua non* to good results in numberless cases. But I would like to call your attention to the contempt for your patients' feelings that a "familiarity" with its application breeds.

You are all aware how quickly you jerk your head away if by accident the floss slips too rapidly between your own teeth and burrows itself in your gums while you are cleansing them. How often the same thing is perpetrated on your patients, and nothing thought of it, by you at least, while you are laying coil after coil of cable on teeth that oftentimes do not require ligatures! Frequently, indeed, they serve only to obstruct access to the cavity. We all know, or should know, that with holes of proper size and shape in the dam the employment of ligatures is necessary only in a limited number of cases, provided the tartar has been removed from about the margins of the gum. But for pure, unalloyed torture, permit me to present to your consideration a clamp and an awkward or heavy-handed operator, and I think there are a few such in the profession.

I speak from experience, for it once fell to my lot to sit in the chair with a clamp on an inferior wisdom tooth, compelling me to keep open house during the space of three and one-half hours. My knowledge now teaches me that it was entirely unnecessary, and that the cavity might have been filled, with the aid of napkins, in less time than it took to get the rubber and clamp adjusted, and with infinitely less pain and discomfort.

Now, I do not maintain that the clamp should be relegated into "innocuous desuetude," but I do say that extreme care should be exercised in selecting the proper ones to be used in each particular case, so that they may be easily adjusted, and that the most delicate and extreme accuracy of manipulation possible be employed while placing them upon the teeth. I know of nothing more repellent to the average patient than the rubber dam and its accompaniments; therefore I think it behooves us to manifest a little compassion by dispensing with the use of the clamp, or the ligature, and even the dam itself, whenever it is practicable.

Another medium for pain-culture, and one which gives ample opportunity for the application of all the reserve abuse we may have stored away, is obtained during a course of regulating. A great deal of pain and soreness, of course, it is needless for me to say, is unavoidable while moving the teeth about, but there is also a large amount carelessly inflicted by over-anxious operators, too eager to accomplish in one day what should take a week, and again doing to-day what they must undo to-morrow.

I once saw a case of regulating that was worthy of the attention of the society for the suppression of cruelty to children. The teeth were very much displaced, and appliances were adjusted to almost all the teeth simultaneously. Too much force was applied, and too long an interval allowed to elapse before changing, so that when I saw the mouth there was scarcely a tooth in the superior maxilla that could not have been easily removed with the fingers. For articulation the patient could not bring the teeth together without suffering intense pain. And all this under the direction of a reputed skillful operator. The effect of such operations is most pernicious, for the impression they produce on the patient's mind is often more enduring than what they effect in the physiognomy, and frequently nothing short of an exposed pulp will permit further dental operations during those years when the closest scrutiny and care should be exercised.

This, then, is the point I wish to make regarding the lack of care to avoid pain during regulating; that oftentimes nothing is gained by the operation, because if you succeed in holding your young patient's interest to a successful termination of the work, you have also generated mentally such an intense dread and abhorrence of you and your benefactions that it is not until caries has obtained a firm foothold, and some-

* Read at a meeting of the American Academy of Dental Science, in Boston, Mass.

times even demolished that which for months engaged all your energies to perfect and beautify, that your ministrations are again solicited. Would it not be more preferable to "make haste more slowly," and retain the confidence of the little ones, even at the cost of not accomplishing quite as much as you would wish to do at that time? This same principle is equally applicable to the filling of young teeth, and I frequently do nothing more at the first sitting than to cleanse a few teeth with the stick, or wipe out a cavity with an antiseptic and insert a little gutta-percha or cement, sometimes without removing any decay whatever. For I consider my time well employed if I can succeed in dispelling this dread which always possesses them at the first sitting.

There are many minor things in our routine work that might be dilated upon in a paper of this kind which are really painful, although to us they seem very trifling, and if our patients shrink from them we are prone to ascribe it to fear or timidity, when we really are inflicting pain. By the habits of some dentists one would suppose the patient had no rights that the dentist should respect. He lolls over and leans on his patient, making of their head a cushion and support for his arm till the patient is well nigh exhausted. It does not diminish the discomfort any to know that it is sometimes done unconsciously. That much inconvenience and unnecessary pain are caused by our neglect to scrutinize our processes and individual peculiarities, or by failure to keep them before our eyes, is not to be denied. Is not unnecessary pain frequently caused while putting on gold caps, bridges, and collars for crowns, without first applying cocaine to the gum margin? Is it not unnecessary pain to continue nibbling at an exposed pulp that had not wholly succumbed to the arsenious paste? I think you will agree with me that to catch the lip beneath the thumb while making it a fulcrum against the teeth is rather painful, and that to wash out a cavity with cold instead of tepid water may produce avoidable pain.

How common an experience it is to hear an outcry, or see a twitching of the head and body immediately upon using the chip blower while excavating! It does not take place so much if we use warm air. Yet, do we always use it? Is it not positively abusive to whack away at a tooth for hours with the automatic mallet, when hand pluggers might be used with so much more comfort, at least during the first part of the filling? Is it not an abuse to inflict quick wedging as ordinarily performed? It is not an abuse in taking full impressions for artificial dentures, to overflow the plaster from your impression-cup into the throat of your patient, when a smaller quantity would produce a much better result by giving a more accurate impression, because the parts are not so likely to be disturbed by retching and coughing? Is it not abusive for a dentist having a strong, muscular hand, with a heavy touch and a vise-like grip, to rush and hurry through his work as if he were under the impulse of electricity? My observations lead me to believe that rapid operators hurt more than slow ones. I believe that after a fair rate of speed has been attained, any acceleration of it is obtained only at the expense of delicacy of touch and of the patient's nervous system.

The conclusions I drew from my experience as a patient was that more pain and discomfort arose from outside influences, if I may so term them, than from the actual preparation of the tooth to be filled. It is within the ability of everybody to cultivate a delicacy of manipulation, if they do not naturally possess it, and delicate manipulation is a powerful factor in dispelling the dread so universal in the minds of the people relative to dentistry. As President Elliot said the other day at the meeting in behalf of Harvard's new dental school, "It is the dread of pain which makes people miserable."—*Dental Journal.*

## THE COMBINATION OF OXYGEN WITH HYDROGEN.

By H. N. WARREN, Research Analyst.

A MIXTURE of two volumes of hydrogen with one of oxygen remains inert until a light is presented to the same—so read our modern handbooks of chemistry. But oxygen, in admixture with hydrogen, becomes closer allied to water on increase of pressure, until a pressure of 180 atmospheres is attained, when combination takes place with fearful violence. The experiments which are thus presented by the author, of which a brief description will suffice, were constructed electrolytically, as may be readily observed to be the simplest and at the same time most efficient mode of dealing with the gases. Small selected glass tubes, into which two platinum wires were sealed, after introducing into each a c. c. of acidulated water and sealing the further extremity, were subjected to the action of an electric current of six volts. The rapid bursting of the first series of tubes, consequent upon the heating of the small quantity of liquid contained therein, at once suggested the cooling of the same by inserting the sealed tube and its contents in a strong glass vessel containing water. A tube thus mounted was next put upon trial; the electric circuit having been established, the experimenters meanwhile withdrawing themselves to a safe distance, carefully timing the effect.

In previous cases of trial the tubes had burst within three minutes, after applying the current, with a slight explosion; but in this case ten minutes had elapsed, and the action continued as energetic as ever. Fifteen and twenty minutes passed, and the action within the minute vessel continued as briskly as ever; exactly twenty-five minutes had elapsed when a vivid flash, succeeded by a violent report, terminated the experiment, shattering the glass vessel and scattering fragments in all directions.

The force of the explosion may be understood from the fact of the sealed tube being but an inch and a half in length, and containing only one c. c. of water; nevertheless, portions of glass were hurled with sufficient force in the immediate neighborhood of the explosion so as to penetrate a wooden bench to the depth of half an inch, while an assistant some distance from the spot narrowly escaped severe laceration. Various other tubes were afterward experimented upon, affording similar results, the pressure, as arrived at by a careful average, amounting to 180 atmospheres.—*Chem. News.*

## SEPARATION OF WOOL AND COTTON.

COTTON and wool may be separated from each other by operating on two samples of the textile material, using a solution of caustic soda in one case and dilute sulphuric acid in the other case. On boiling, the wool will be removed in the first case, while the cotton will be left; in the second case, the cotton will be removed, while the wool will be left. The fibers are then in a condition fit for further examination if required.

If a sample be heated for some time to 280° F., the wool can be rubbed out as dust, while the cotton will only be rendered slightly tender. Of course, in this case the character of the wool as regards staple, etc., will be lost.

If a sample be dipped into dilute sulphuric acid and hung up for some time in a warm place, the cotton will be destroyed; on washing and drying, the weight of wool is obtained. The loss is due to cotton, size, starch, mineral matter, etc.

Undyed mixtures may be boiled in a weak solution, say of eosine; wool takes a faint pink color, the cotton is unaltered. Dyed mixtures may, in most cases, be recognized by the action of dilute acids; especially if dyed in the piece, and in many cases if dyed in the hand.—*Thos. T. P. Bruce Warren, in Chem. News.*

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## TABLE OF CONTENTS.


PAGE

I. BIOGRAPHY.—Galileo Galilei.—The life of Galileo, with numerous views of scenes connected with his life.—14 illustrations. .... 14507

The Galileo celebration at Padua.—Notes on the celebration of the 300th anniversary of Galileo's professorship at Padua.......... 14504

II. CHEMISTRY.—Separation of Wool and Cotton.—An excellent method for separating the two staples in analyzing fabrics.... ... 14518

The Combination of Oxygen with Hydrogen.—By H. N. WARREN.—The explosive combination of these two gases brought about by increase of pressure, and simple method of carrying out the experiment.......... 14518

III. MECHANICAL ENGINEERING.—The Genesis and Exodus of Steam.—By GEORGE H. BABCOCK.—A very valuable and practical paper on steam and its functions.—A Sibley College lecture....... 14508

The Manufacture of Bicycles.—The details of this branch of manufacturing, now become so great an industry.—15 illustrations.......... 14511

IV. MEDICAL.—The Origin of the Sigmoid Flexure and the Appendicula Vermiformis of the Human Colon.—A curious view of the origin of the visceral features of the human organization.......... 14516

Unnecessary Pain in Dental Operations.—By JAMES A. REILLY.—A plea for gentleness in dental practice.—How to avoid pain in treating the teeth.......... 14517

Water Cures from Clinical and Experimental Points of View.—By Prof. WILHELM WINTERNITZ.—What can be done by hydropathy.—A paper from an investigator of thirty years' standing.... 14515

V. METALLURGY.—The Utilization of Blast Furnace Slag.—By Herr R. ZSIGMONDY.—Different methods of utilizing this waste product of the metallurgist.—Bricks, plaster, and cement made with slag.......... 14514

VI. NAVAL ENGINEERING.—The Austrian Torpedo Cruiser Satellit.—A twenty-two and a half knot cruiser.—Her recent trial by the Austrian government.—2 illustrations.......... ... 14510

The Best All-Around Modern Ship.—Notes of the ships in the recent naval pageant.—Testimony to the merit of the United States ship New York.......... 14510

The Draughtometer.—An apparatus measuring the depths of ships' draughts.—2 illustrations.......... 14509

VII. PHYSIOLOGY.—The Sensitiveness of the Eye to Light and Color.—By Capt. W. DE W. ABNEY.—The subjective aspects of color.—How they affect the eye in nature, with experimental illustrations of the same.—5 illustrations.......... 14505

VIII TECHNOLOGY.—Camphor Manufacturing in Japan.—A very graphic and interesting article on this little known industry, with illustration of the appliances used by the Japanese.—1 illustration 14514

Vegetable Wax.—Note on the great variety of vegetable waxes as produced in the Orient, and how are they produced.......... ... 14517